مجلة تاريخ العلوم العربية

فايز

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الثاني
١٩



معهد التراث العلمي العربي
جامعة حلب ـ سورية





المجلد الثاني　　العدد الثاني　　تشرين الثاني ١٩٧٨

محتويات العدد

القسم العربي

الابحـاث :

القسم الأجنبي

الابحـاث :

مجلة تاريخ العلوم العربية

تصدر مجلة تاريخ العلوم العربية عن معهد التراث العلمي العـربي مرتين كل عام (في فصلي الربيـع والخريف) • يرجى ارسال نسختين من كل بحث أو مقـال الى :
معهد التراث العلمي العربي ـ جامعة حلب .

توجه كافة المراسلات الخاصة بالاشتراكات والاعلانات والأمـور الادارية الى العنوان نفسه • يرسل المبلغ المطلوب من خارج سورية بالـدولارات الامىركية بموجب شيـكات باسـم **الجمعية السورية لتاريخ العلوم**

قيمة الاشتراك السنوي :

المجلد الاول أو الثاني (١٩٧٧ ، ١٩٧٨)

بالبريد العادي المسجل :	٢٥	لبرة سورية أو ٦ دولارات أمىركية
بالبريد الجوي المسجل :	٤٢	لبرة سورية أو ١٠ دولارات أمىركية

المجلد الثالث (١٩٧٩)

بالبريد العادي المسجل : كافة البلدان	١٠ دولارات أمىركية
بالبريد الجوي المسجل : البلاد العربية والاوروبية	١٢ دولاراً أمىركياً
آسيا وأفريقيا	١٥ دولاراً أمىركياً
الولايات المتحدة ، كندا واستراليا	١٧ دولاراً أمىركياً

مطبعة جامعة حلب

مقالة
في التطرق بالطب الى السعادة
لعلي بن رضوان

تحقيق

سلمان قطاية *

نقدم ولأول مرة النص الكامل لمخطوطة « مقالة في التطرق بالطب الى السعادة» لعلي بن رضوان . وهو النص الوحيد المحفوظ حتى اليوم في مكتبة حكيم علي أوغلو باشا تحت الرقم ٦٩١ (٣) – ف ٨٩٤ .

ولقد تفضل معهد المخطوطات العربية بالقاهرة مشكورا ، فأمدّنا بصورة عنها. والمقالة هذه على قصرها تتمتع ببعض الاهمية .

فهي : اولاً تساعدنا على تحديد زمن ولادة علي بن رضوان ، وبالتالي عمره ، فالمعلوم أن تحديد سنة ولادة العلماء القدامى عسير عادة .

وقد ورد في كتاب « عيون الانباء » لابن أبي اصيبعة (١) عن ابن رضوان نُبذ من سيرته الذاتية يقول فيها « . . . وكان يفضل عني الى وقتي هذا ، وهو آخر السنة التاسعة والخمسين . » ويقصد التاسعة والخمسين من عمره .

كما ذكر ماكس مايرهوف (٢)، خلال سرده القائمة الكاملة لمؤلفات ابن رضوان، أن ثمة ثلاثة مؤلفات ربما كانت كلها واحدة أو متشابهة وهي :

* كلية الطب – جامعة حلب .

١ – ابن ابي اصيبعة – عيون الانباء في طبقات الأطباء – طبعة بيروت – ١٩٦٥ . ص : ٥٦١ .

2. - M. Meyerhof, *The Medico-Philosophical Controversy between Ibn Butlan of Baghdad and Ibn Ridwan of Cairo*, Egyptian University - Faculty of Arts Publication No. 13, (Cairo 1937) pp. 41 - 49.

— سيرته المذكورة في كتاب عيون الانباء .

— ومقالة في التطرق بالطب الى السعادة .

— ومقالة في سبيل السعادة ، وهي السيرة التي اختارها لنفسه .

فاذا عدنا الى مقالة في التطرق ، رأينا ابن رضوان يقول « . . . وجدنا تاريخ الاسكندر الى وقتنا هذا هو سنة ست وثلاثين واربع ماية للهجرة . . » .

فاذا اعتبرنا هذا التاريخ (اي عام ٤٣٦ هـ / ١٠٤٤ م) هو العام الذي بلغ فيه ابن رضوان سن الستين ، استطعنا القول أنه ولد عام ٣٧٦ هـ / ٩٨٦ م ، وتوفي عام ٤٥٣ هـ / ١٠٦١ م (حسب ابن ابي اصيبعة) أو ٤٦٠ هـ / ١٠٦٧ م (حسب القفطي) ، وأنه عاش بين الخمس وسبعين عاما والواحد والثمانين .

ونجد في المقالة نفسها معلومات تلقي بعض الضوء على مفهوم ابن رضوان عن التعليم الطبي الذي اهتم به كثيراً وذكره في معظم مؤلفاته ، بل كرّس له كتاباً بعنوان « النافع في كيفية تعليم صناعة الطب » [3] .

ولا بد أن منشأ هذا الاهتمام هوممارسته للتعليم والتدريس في بيمارستانات مصر . والمعلوم أن ابن رضوان اشتهر بقوله بأنه يمكن تعلّم الطب بدون استاذ (كما فعل هو نفسه اذ لم يُعرف له شيخا تتلمذ على يديه) ، وانه انتُقد كثيراً بسبب ذلك [4] .

ففي كتاب « النافع » يدعي بأن التعلّم عن الكتب لوحدها ممكن انما ضمن شروط خاصة فيقول « وهذه الطريق يقوم لمن لا يجد معلما جيدا مقام المعلم الجيد » كذلك فهو ليس بمقدور الا « ذوي القرائح الجيدة والطبائع الفائقة » .

وفي مقالة « التطرق » يعود فيؤكد هذه الفكرة فيقول « وليس يخلو المتعلم لها (أي صناعة الطب) من أمرين :

٣ — توجد نسختان : واحدة في دار الكتب المصرية بالقاهرة رقم : طب ٤٨٣ . والثانية في مكتبة تشستر بيتي في دبلن (رقم : ٤٠٢٦) .

٤ — ابن ابي اصيبعة — العيون — بيروت — ١٩٦٥ ص ص : ٥٦٣ — ٥٦٣ .

١ ـ اما أن يجد معلما فاضلا يفهم منه ما في كتب ابقراط فيسرع بذلك تعلمه كما أسرع تعليم جالينوس .

٢ ـ واما أن يُعدم المعلم الحاذق فيحتاج أن يتعلم لنفسه من كتب جالينوس فيطول زمان تعليمه .

ثم يشير الى أن القسم العملي من الطب لا يتم تعليمه الا : « بمعاينة هذه الاعمال بين يدي أفضل من تعلم عليه من اهلها » .

وهنا تبدو لنا أهمية مقالة « التطرق » لانها تقدم تفاصيل جديدة غير معروفة عنه ، وتجعل فكرته عن التعليم الطبي مقبولة الى حد ما . رغم اعتقادنا الجازم بأنه لا بد من معلم لكل من قسمي الطب : النظري والعملي .

ثم يكرس ابن رضوان الباب الثالث من المقالة لموضوع عنوان المقالة ، فيشرح مفهومه الفلسفي عن مهنة الطب .

وهو مفهوم مثالي مطلق فيقول « قال جالينوس في آخر المقالة الاولى من حيلة البرء : وينبغي لنا أن ننافس ونباهي الملائكة في فعل الخير » .

والفكرة هذه مشروحة بشكل مفصل في كتابه « في شرف الطب » . وهو مفهوم ديني مرتكز على أن الطب هو فعل الخير وواسطة لارضاء الله والفوز بالجنان ، ويعترف انه رغم ذلك فان الطب في ايامه (كما في كل زمان وعصر) لم يكن يخلو من الدجل والشعوذة .

ويبدو لنا أنه من الضروري التمييز بين من يختار مهنة الطب عن ايمان ديني عميق لا يريد منه سوى كسب مرضاة الله وهم الندرة . والغالبية التي لا ترى في الطب الا وسيلة لكسب المال والحياة الرغيدة . وهذا ما لم يره ابن رضوان ، أو رآه ولم يعترف به .

وينتقــل ابن رضوان في مقالة «التطرق» الى تاريخ الطب قبل الاسلام . ونراه

لا يقدر أو يحترم الا ابقراط وجالينوس[٥] . وخاصة هذا الاخير . اذ يعتبر كتبه فوق كل نقد ، أو شك ، بل ينتقد بقسوة كل من يتعرّض لنقده (كالرازي مثلا) .

وتلك نقطة ضعف في مؤلفاته ، لأن الفكر العلمي يبحث دوما عن الحقيقة : وهو في سبيل ذلك لا يتوانى عن مناقشة كل رأي بفكر علمي موضوعي .

٥ – شرح ابن رضوان ستة كتب لجالينوس هي . كتاب الصناعة الصغيرة – كتاب الاسطقسات – كتاب النبض الصغير – بعض كتاب المزاج – كتاب جالينوس الى اغلوقن – في التأني لشفاء الامراض – (ابن ابي اصيبعة – العيون – ص : ٥٦٦) .

بسم الله الرحمن الرحيم

مقالة علي بن رضوان في التطرق بالطب الى السعادة وهي ثلاثة ابواب :

الباب الاول – في كتب ابقراط .

الباب الثاني – في تعريف ابقراط .

الباب الثالث – في التطرق بالطب الى السعادة .

الباب الاول
في كتب ابقراط

قال علي بن رضوان : قد بيّنا في كتبنا (٦) ان ابقراط استكمل تعليم صناعة الطب وان جالينوس هذب تعليم ابقراط ، فصيّر صناعة الطب ميسّرة سهلة التناول على من زاولها من ذوي الطبائع الفايقة ، واما غير هاؤلاي فقد نهى ابقراط وجالينوس معاً عن تعليم هاؤلاي متى انتحلوها فهم فيها اطباء بالاسم لا اطباء بالفعل ، لتقصير طبائعهم عن ادراكها . ولذلك هم السبب في ذمّها . واوضحنا انه ينبغي ان يكون المتعلم لها طبيعة مواتية ، وذهن ذكي ، وحفظ جيد ، وحرص شديد ، واحتمال للتعب ، وحب للجميل .

وان يكون قبل تعلمها قد تأدّب بالآداب والتعاليم فقد ذكر جالينوس(٧) في مقالته في ترتيب قراءة كتبه : انه شرع في تعليم الطب بعد رياضة في التعاليم والآداب ، وقد بلغ في السن السنة السابعة عشر .

٦ – ربما كان يقصد كتاب: " النافع في كيفية تعليم صناعة الطب " بشكل خاص . وهو مخطوط غير مطبوع .

٧ – Galien ولد حوالي عام ١٣٠ م في برغاس في ميسيا وتوفي حوالي سنة ٢٠٠ م ويدعي البعض انه توفي عام ٢١٨ م . وهو من اكبر اطباء اليونان . وكتبه الستة عشر اشهر من ان تذكر.

وقال في غير هذه المقالة : انه وضع كتابا في الاسطقسات ، وهو ابن تسعة عشر سنة . وما كان يضع ذلك الا بعد استكماله تعليم صناعة الطب ، وذلك أنه عرف في تفسيره كتاب طبيعة الانسان لبقراط ، وضعه بعد ان وقف على آراء ابقراط ، وفهم ما في كتبه بقراءته اياها على حذّاق المعلمين ، فحصل زمان تعلمه الطب ثلاث سنين فلذلك ينبغي (أن) يقتدى به في تعليم هذه الصناعة، فيتأدب اولا في الاداب، ويرتاض في التعاليم ، ثم يقرأ كتب ابقراط ، ويفهم معانيها . لم يكن احدا قبله هذبها تهذيبه .

فالحاصل من ذلك انه يمكن تعليم صناعة الطب في ثلاث سنين . وقد اشترط ابقراط في تعليمها شروطاً منها ما ذكرته اولا من حال طبعه للتعليم ، ومنها ان يكون حديث السن ، وهو من كان عمره ما بين سن البلوغ وبين خمس وعشرين سنة ، لان المزاج على هذا السن اعدل منه في سائر الاسنان ، وقوى النفس تابعه لمزاج البدن .

وليس يخلو المتعلم لها من احد امرين :

– اما ان يجد معلما فاضلا يفهم منه ما في كتب ابقراط فيسرع بذلك تعليمه كما اسرع تعليم جالينوس .

– واما ان يعدم المعلم الحاذق فيحتاج ان يتعلم لنفسه من كتب جالينوس فيطول زمان تعليمه متى استعمل في تعليمه قوانين المنطق .

ولأن صناعة الطب صناعة فاعلة لم يمكن تعليمها خلُوّاً من منازلة اعمالها الجزئية، كما بين ذلك ارسطوطاليس فيما بعد الطبيعة : ان كل صناعة فاعلة انما تحصل وتكمل بمعرفة قوانينها الكلية ، وبمنازلة أعمالها الجزئية .

فاذن : المتعلم لصناعة الطب ، مع قراءته كتب ابقراط ، يلزمه ضرورة ان ينازل بنفسه اعمالها الجزئية . وذلك يتم بمعاينة هذه الاعمال الجزئية بين يدى افضل من تعلم عليه من اهلها . وقد وضع جالينوس لكتبه التي هذب فيها تعليم بقراط ولخصه فهرست(٨) ولقرائتها ترتيبا . فالمتعلم يأخذ ذلك مــن جالينوس : واما كتب بقراط

٨ – كتب على الهامش : فكتبت الى رفيقي يحيى بن سعيد في ذلك فجاءني منه فهرستها .

فلم يقع لي فيما سلف لها فهرست، ذكر انه ترجمه من اليوناني الى العربي. فقرأته فوجدت الكتب غير مرتّبة ، ولم يتفق حصول جمعها عندي فأرتب قراءتها. وذلك انه يعوزني منها نحو اثنا عشر مقالة فرأيت ان أنسخ لي في هذا الموضع ما وصل الي من فهرستها على هيئته . وهذا هو : ١ ظ

كتاب الناموس مقاله (٩)
كتاب الوصية مقالة
كتاب العهد مقالة
* كتاب الفصول سبع مقالات
* كتاب تقدمة المعرفة ثلاث مقالات
* كتاب قاطيطريون ثلاث مقالات
كتاب تقدمة الانذار مقالتان
كتاب تقدمة الانذار المنسوب الى اهل قــو
كتاب الامراض ثلاث مقالات
كتاب تدبير الامراض الحادة و هو كتاب ماء الشعير ثلاث مقالات
* كتاب الغذاء اربع مقالات
كتاب التدبير ثلاث مقالات
كتاب استعمال الرطوبات
كتاب الادوية
كتاب الحقن
* كتاب ابيذيميا سبع مقالات
كتاب الاعظم في العلل
كتاب العلل الباطنة

٩ – لقد نسب الى ابقراط كتب كثيرة ويقول ابن ابي اصيبعة (العيون – ص ٥٣) " والذي انتهى الينا ذكره ووجدنا في كتب ابقراط الصحيحة يكون نحو ثلاثين كتابا . والذي يدرس من كتبه لمن يقرأ صناعة الطب ، اذا كان درسه على اصل صحيح وترتيب جيد ، اثنا عشر كتابا وهي المشهورة من كتبه ".
ولقد وضعت اشارة * الى جانب كل كتاب من هذه الكتب الاثني عشر ، ورد ذكره في قائمة علي بن رضوان

كتاب المرض الكاهني
كتاب الاسابيع مقالة
كتاب النفخ مقالة
* كتاب الاهوية والبلدان والمياه اربع مقالات
كتاب الطب القديم
كتاب الصناعـــة
كتاب البصـــر
* كتاب الاخلاط ثلاث مقالات
كتاب الورم
كتاب الجراحات القاتلة
كتاب خراجات الرأس
كتاب انتزاع البثور(١٠)
كتاب البواسير
كتاب النواصير
كتاب الكسر والرض
كتاب المفاصل
كتاب نهايات الامراض
* كتاب طبيعة الجنين ثلاث مقالات
* كتاب طبيعة الانسان ثلاث مقالات
كتاب المواضع التي في الانسان
كتاب المولودين لسبعة اشهر
كتاب المولودين لثمانية اشهر
كتاب المولودين لتسعة اشهر
كتاب حَبَل على حَبَل
* كتاب الكسر(١١)

١٠ – في الاصل : البثول .
١١ – في الاصل: السر . وفي قائمة ابن ابي اصيبعة ورد اسمه "كتاب الكسر والجبر . ويقول هذا (العيون – ص ٥٥) " ولابقراط ايضا من الكتب وبعضها منحول اليه . . "

كتاب تقطيع الجنين الميت
كتاب في الامراض
كتاب نبات الاسنان
كتاب العذارى
كتاب تدبير النساء
كتاب من يبول الدم
كتاب علل النسا
كتاب النساء اللواتي لا يحبلن
كتاب الجبر
كتاب السابع
كتاب البدع
١ كتاب اعتقاد اهل اثينا
فذلك خمس وخمسون كتاباً .

قال علي : وليس هي مرتّبة . ويمكن ان ترتّب ترتيبين : احديهما يليق باصحاب التجارب(١٢) وهي ان يبدأ بقراءة قاطيطرون ، وتفسيره حانوت الطبيب ، ثم نثني بعده كتاب الكسر والرض ، ثم كتاب الجبر ، ثم كتاب الخراجات ، ثم سائر الكتب العلمية على ترتيب ما ينبغي ان يقرأه شيئا بعد شيء .

فاذا فرغت الكتب العملية ، يبدأ بعدها بكتاب طبيعة الانسان . وترتيب القراءة فيها على ما ينبغي .

والترتيب الاخر يليق برأى اصحاب القياس : وهو ان يبدأ بقراءة كتاب طبيعة
٢ الانسان ثم يوالي القراءة على ما ذكرت ويحفظ ظاهر كتاب الفصول ، وكتاب تقدمة المعرفة فاذا فرغت كتب علم هذه الصناعة يبدىء بقراءة كتاب قاطيطرون وما بعده على حسب ما يوجبه العمل .

١٢ – Empiriques . والمعلوم انه كان ثمة ثلاث مدارس طبية يونانية :
اصحاب القياس Dogmatistes – الذين يعتمدون على الملاحظة والمنطق .
واصحاب الحيل Méthodistes الذين يعتمدون على مقارعة المرض باية طريقة كانت لشفائه واهمهم طاليس Thessalus . واصحاب التجارب – الذين كانوا يعتمدون على نتائج التجربة العملية العلاجية .

الباب الثاني

في تعريـــف ابـــقراط(١٣)

ويقال ان معنى هذا الاسم : ماسك الفرس .

قالوا : انه اتفق لرجل كان شديد القوة انه ضرب بيد الواحدة الى رأس او عنق فرس هايج ، وضرب بيد الاخرى الى اصل ذنبه ، فمسكه قائما لا يقدر يتحرك . فتعجب الناس من شدته وسموه بقراطيس اي ماسك الفرس واشتهر هذا الاسم في اليونانيين ، فضرب به المثل لكل من كان من الناس شديد القوة ، الى ان صار اليونانيين يسمون ابنائهم كما نحن نسمي ابنائنا اسد وصاعد نحو ذلك الى يومنا هذا .

والمشهور هذا الاسم مـــن علمـــاء اليونانيين خمسة رجال : احدهم ذكره ارسطوطاليس(١٤) في المقالة الاولى من السماع الطبيعي ، وفي غيرها اعاد ذكره على انه رجل مهندس ظن انه وجد مربع الدائرة . فان هذه المسألة مختلف فيها الى يومنا هذا بين المهندسين. والاربعة الباقون اطباء ذكرهم جالينوس في تفاسير كتب ابقراط فقال في مقالته في المولود لسبعة اشهر : لقد اختلف المفسّرون لكتب الفاضل ابقراط . منهم من قال : ان جميع هذه الكتب وضعها ابقراط واحد ، ومنهم من قال : انها ليست لواحد . وذلك ان القوم الذين كانوا يسمّون بهذا الاسم ، اعني ابقراط ، اربعة نفر يتلو بعضهم بعضا واولهم : بقراط ابن اغنوسيديقس والثاني : بقراط بن ايراقليدس ، والثالث : بقراط بن باساكوس(١٥) ، والرابع : بقراط ابو دراقن ولجميعهم كتب .

وقال في تفسيره المقالة الثانية من كتاب طبيعة الانسان : بقراط الكبير له ولدان احدهما تاسالس(١٦) ، ، والاخر دراقن . ولكل منهما ولد سماه بقراط .

قال علي : وعرف جالينوس ذلك في مواضع أخر من كتبه . وقال : ان تاستالس بن بقراط كان من المتقدمين في صناعة الطب . لكنه لم يخلف اباه بقراط في التعليم بمدينته .

١٣ – ويسمى ايضا بقراط ويلقب بالكبير والحكيم والفاضل والالهي وابي الطب توفي حوالي عام ٣٥٧ ق . م .
١٤ – ويكتب ايضا ارسطو فيلسوف يوناني شهير (٣٨٤ – ٣٢٢ ق . م) .
١٥ – لعلها – تاسالوس
١٦ – في الاصل – تاستالوس

لكن صَحِبَ ارسالاوس الملك والذي خلف بقراط في التعليم تلميذه فولوبس ، وذلك ان بقراط بن ايراقليدس كان له جماعة من التلاميذ وولداه تاسايس[١٧] ودراقن ، ولم يخلفه في التعليم سوى تلميذ فولوبس ، وذكر ان المقالة الثالثة من كتاب طبيعة الانسان التي هي حفظ الصحة لفولوبس[١٨] ، وان المقالة الثانية من كتاب ابيذيميا لتاسالس[١٩] وان قوما نسبوا كتاب المولودين لثمانية اشهر الى فولوبس . وبالجملة فليس ما وضعه هاؤلاي الرجال السبعة الاربعة المسمون ببقراط ، والثلاثة تاسالس[٢٠] ودراقن الى بقراط بن اراقليدس لان هو الذي خرج له الاسم وكان افضل القوم ، وافضل جميع من كان في عصره ، ومن تقدمه ومن تأخر الى يومنا هذا من الاطباء .

فلذلك سمي بقراط الكبير وشاع اسمه في الدنيا في حياته ، وبعد وفاته الى ابد الابدين ، ما دام الناس موجودين . ولقد بلغ من امره في حياته ان ملك الفرس المسما بملك الملوك ارطحششت [٢١] بذل [٢٢] له مائة قنطار ذهب ، والهبات العظيمة [٢٣] ، وحرائر فاخرة على ان يسير اليه ويخدمه بالطب فما فعل ولا اجابه . وبذل له اهل ابديرا [٢٤] عشر قناطير ذهب على علاج حكيمهم دمقراط[٢٥] لما ظنوا انه يغير عقله ، فرد المال ومن عليهم وسار اليه معهم ، فلما شاهد دمقراط علم انه صحيح ، وانه لما اشتغل بالعلم عن تدبير مدينتهم ظنوا انه قد تغير عقله ، فاعلمهم بقراط انه صحيح وانه آثر الانفراد والخلوة بالنظر والفلسفة والسكون عن تدبير المدينة . وانصرف عنهم الى مدينته قو . ولأبقراط اخبار كثيرة ، وعجايب جدا ، تدل على فضيلة عظيمة ، وشرف عظيم . وانا اثبت وضع بقراط في المعمورة ، ووضع مدن الحكما المشهورين بالحكمة الصحيحة ، فان بطلميوس[٢٦] صحح وضع هذه المدائن في كتابه في صورة المعمورة من الارض فمنها قو مدينة ابقراط : فطولها مد درجة ، وعرضها كـــر درجة . واما فرغاس مدينة

١٧ – في الاصل – تاستالس
١٨ – في الاصل – لولوبس
١٩ – في الاصل – لتاسالس
٢٠ – في الاصل – تاسالس
٢١ – في الاصل – اذ طحســت والاغلب انه ازدشير والافضل اردشير وجاء في العيون ان ابقراط كان في عهد " بهمن بن ازدشير "
٢٢ – في الاصل – ابذل
٢٣ – في الاصل – عظيمة .
٢٤ – جزيرة يونانية صغيرة اشتّهر اهلها بخفة العقل .
٢٥ – اوديمقراطيس وهو فيلسوف تلميذ ارسطو وعاش في حدود عام ٤٥٩ ق . م .
٢٦ – ويسمى ايضا بطلماوس وبطليموس وابطليميوس وبطلميوس (٢٨٥ – ٢٤٦ ق . م .).

جالينوس : فطولها دله وعرضها مآر واما اثينا مدينة الحكماء ، وهي مدينة سقراط[٢٧] وافلاطون[٢٨] : فطولها يب م وعرضها لذك . فجميع هاؤلاي في الاقليم الرابع وفي النصف الغربي من المعمور قريب من منتهاه الى جهة المشرق المحاور لاشياء وذلك ان الحكمة نقلها من مصر بالس الملطي[٢٩] ، وفيثاغورس[٣٠] الى اليونانيين . لانهما سافرا الى مصر وتعلما من حكمائها وسارا الى اليونانيين فاظهرا ما تعلماه من اهل مصر ، لان مصر كانت في القديم دار الحكمة والعلم ، وهذه الحكاية يشهد بصحتها كتاب التوراة ، وقد كتبها فلاطن وارسطوطاليس في كتبهما ، ودونها فرفوريوس وغيره ممن عني بكتب تواريخ الحكماء من الفلاسفة والاطباء ، وذكر جالينوس في كتبه ان الطب اقتصر عليه اسقلبيوس[٣١] . واسقلبيوس مختلف فيه فطائفة زعمت انه ملَك بعثه الله عز وجل فعلّم اهل هذا البحث صناعة الطب فسمي على عادة القدماء في تسمية المعلم اباً للمتعلم . وطائفة زعمت انه رجل اوحي اليه الطب واستخرج هو ايضا من تلقاء نفسه ، واليه تكسب الاطباء في سالف الدهر ، وذلك ان الطب كان اولا بجزيرة رودس[٣٢] اخــذه اهلها عن حكماء المصريين ثم انتقل الى اهل هــذا البيت بجزيرة قنيدس[٣٣] ، ثم انتقل الى جزيرة قو[٣٤] .

اما جزيرة رودس فطولها ع ر وعرضها لـــو ، واما جزيرة قنيدس فطولها لويه وعرضها لو ، واما جزيرة قو فطولها ع مر وعرضها فيما سلف .

وكان الطب في هذا البيت يتعلمه الولد من ابيه وجده فقط ، ولا يمكن غريب
ه تعليمه الى ان نشأ ابقراط بن ايراقليدس المشهور بالفضيلة ، فخاف على الطب ان يبيد ويفسد . فشرط شروطا انت تقف عليها من كتاب الناموس والوصية والعهد على المعلم

٢٧ – اسقراطيس فيلسوف يوناني حكم عليه الموت بالسم .

٢٨ – في الاصل – فلاطون . وهو الفيلسوف اليوناني المثالي (٤٤٧ – ٣٤٧ ق . م) .

٢٩ – بولس الاغنيطي او القوابلي – احد اطباء مدرسة الاسكندرية

٣٠ – Pythagore حكيم يوناني . زار مصر وبابل والشام . ويعزى اليه تقويم الحساب المعروف بجدول فيثاغورس في الضرب . توفي في جزيرة ساموس (حوالي عام ٢٠٠ ق . م) .

٣١ – يسمى ايضا اسفيلبيوس واسقليبيازيس .

٣٢ – Rodos ٣٣ – Cnidos ٣٤ – Cos

والمتعلم . فمن الزم نفسه تلك الشروط وكانت فيه ، اباحة التعليم ، كان من نسله او من غير نسله . وكان تلميذه فولوبس افضل تلاميذه ولم يزل الطب ينتقل من واحد الى واحد الى ان انتهائه الى جالينوس ، وليس هو من نسل اسقليبوس ، فزيف جالينوس [٣٥] الاقاويل الفاسدة وبهرج الاراء الكاذبة الردية وهذب صناعة الطب فيما وضعه من التفاسير لكتب ابقراط ، ومن كتبه وعرف في تفاسير وكتب ابقراط الاقاويل المدلسه عليه التي دلستها الناس السوء على انها يسيرة جدا بالقياس الى ما في هذه الاراء الصحيحة التي اخفي فيها ذلك التدليس ، فاذا كان كذلك لا فائدة محددة في كتب غير بقراط وجالينوس سوى الكتب التي نص عليها مثل كتاب ديسقوريدس[٣٦] في الادوية المفردة ، ومـا سوى لا ينتفع به وضار لا محالة بالمتعلمين . اذ كان لا يمكن علاج مرض حتى يعرف اوقاته الكلية والجزئية فيعطى في كل واحد منها ما ينبغي ، وهذا لا يمكن الا ان يفهم كتاب الفصول ، وكتاب تقدمة المعرفة ، وكتاب البحران ، وحيلة البرء .

واذ قد ذكرنا مدائن الحكماء ، وانا نزيد في تعريف بقراط بمعرفة تاريخه وتاريخ كل واحد من الحكماء المشهورين بالفضيلة فاقول : ان جالينوس يقول في غير موضع من كتبه انه كان على عهد ادريانوس الملك وانه تخصص بخدمة انطونيس وهو الذي ملك بعد وفاة ادريانوس. وقد بلغني في ذلك حكاية حكاها في كتابه المعروف بالادوية (المقابلة) [٣٧] للأدواء نحو ثلثي المقالة الاولى بأن جالينوس اتى لما اتخذت الترياق لانطونيس الملك رأيت اواني عنده مملوه دار صيني[٣٨] بعضها خزن عـلى عهد طراباويوس وبعضها على عهد ادريانوس ، ورأيت جميع اصناف الدار صيني التي جذبتها واحد يفضل كل منها على صاحبه في القوة والضعف والطعم والرائحة بحسب تقادمه في الزمان الاول من

٣٥ – نستغرب مثل هذه الصفات ان ينسبها علي بن رضوان الى جالينوس . لان علي مثل الرازي والكثيرين من الاطباء العرب يتحدثون عن بقراط ولكنهم لا يقرأون ويستشهدون الا بكتب جالينوس . ولقد فسر وشرح ابن رضوان ستة كتب لجالينوس . وخلال كل ما قرأناه من كتب ابن رضوان نجده تلميذا متحمسا جداً له .

٣٦ – ويسمى ايضا دياسقوريدوس ويلقب بصاحب النفس الزكية والسائح والحكيم الحشائشي والعين زربي عاش في القرن الاول والثاني بعد الميلاد . وله كتاب الحشائش الشهير .

٣٧ – غير مفهومة .

٣٨ – Cinnamomum Zeylanieum وهو نبات يشبه القرفه (انظر احياء التذكرة – رمزي مفتاح) – القاهرة ١٩٥٣ – ص : ٢٩٢ – وكتاب المفردات لا بن البيطار (– بولاق – ص ٨٧) .

اصناف الدار صيني فاتخذت منه معجونا لمرقس الملك المسمى انطونيس فوجدت ذلك المعجون افضل من سائر المعجونات ، حتى ان الملك لما ذاقه لم يدعه مدة من الزمان ، كما يفعل سائر المعاجين الى ان يستحكم(٣٩) ، لكنه استعمله على المكان(٤٠) من غير ان تنزله شهرين . فلمـــا ورث الملك بعد فورمودس الذي لم يعن لا بالترياق ولا بالدار صيني ، ضاع ما كان معي من تلك الشجرة ، وكلما جلب من الدار صيني بعد اندرانوس حتى ان ملكنا سورس امر ان يتخذ له الترياق على ما كان يتخذ لانطونيس ، فاضطررت ان اختار لعمله من الدار صيني ، فبينت من ذلك الترياق بيانا واضحا انه اضعف على انه ، لم يكن مضى على الدار صيني ثلثون سنة كاملة .

قال عـــلي : وبطلميوس في كتاب المجسطي(٤١) انه رصد ثلاث كسوفات قمرية باسكندرية في عقر ادريانوس الملك ويقول في المقالة الثالثة : ورصدنا نحن ٣ و الاستواء الخريفي بغاية الاحتياط والتحرز من الخطأ في السنة الثالثة لانطونيس وهي سنة اربع ماية وثلثة وستين من وفاة الاسكندر .

قال علي : فجالينوس إذاً معاصر بطلميوس ، وعدت الى جداول سني الملوك فوجدت بين وفاة الاسكندر وبين اول ملك انطونيس الذي اسمه مرقس اربع ماية وستين سنة ، فهذا تاريخ صحيح لا شبهة فيه ، وان ارسطوطاليس معاصر للاسكندر . وان فلاطن معلم ارسطوطاليس ، وان سقراط معلم فلاطن وجالينوس ، يقول بلفظه في اخر المقالة الاولى من تفسيره لكتاب طبيعة الانسان ، لما استشهد فلاطن الفيلسوف انه اخذ عن بقراط قال فلاطن : كان قريب العهد بتلامذة بقراط ، وفي جداول تاريخ الملوك ملك الفرس المعاصر لافلاطن كان المسمى ارسيس آخوس وبين هـــذا الملك وبين وفاة ارطخششت الذي كان معاصر بقراط ماية واربع سنين ، فبين اذن ان سقراط لقي (تلميذ) (٤٢) بقراط سمافولوبوس وتعلم منه ، ولذلك القى على فلاطن ما ذكره من كلام ابقراط في طبيعة الانسان واستحسن طريقة ، فسلكها في معرفة طبيعة النفس ، فاذن بين وفاة ارطخششت الذي كان بقراط معاصره ومن قبل الاسكندر له من السنين ماية

٣٩ – اي – حتى ينضج
٤٠ – اي – فورا .
٤١ – Almagest
٤٢ – في الاصل – تلاميذ .

واحدى وعشرون سنة الى ان توفي الاسكندر سنة ست عشر سنة ، فجمع ذلك مابة وسبعه وثلثون سنة ، واذا اضيف اليه ما بين رصد بطلميوس وبين وفاة الاسكندر كان ما بين بقراط وجالينوس من السنين خمس مابة وسبعة وثلثون سنة . واذا قابلنا ما استخرجنا من هذا الحساب ما ذكره يحيى النحوي في تاريخه وتفسيره كان للادوية المقابلة للادواء ، وجدنا يحيى النحوي(٤٣) يقول : مــن زمن وفاة بقراط الى ظهور جالينوس ستماية وخمس وستون سنة وان بقراط عاش خمسة وسبعين سنة ، وجالينوس عاش سبعة وثمانون سنة منها صبيا ومتعلما سبع عشر سنة ، وعالما ومعلما سبعون سنة .

قال علي : فالخلف اذن بين التاريخين سبعة وسبعون سنة فان كان ابقراط توفي في عصر ارطخسست اربعة وعشرون سنة ولذلك ان كان ما ذكره يحيى هو الذي علمناه جالينوس صح قوله وان لم يكن كذلك فقد عرض له سهو في التاريخ اصح واوفق ، لانا اخذناه من قبل بطلميوس وبجدول تاريخ الملوك وليس في ذلك شبهة ولا شك وهو ان بين جالينوس ، وبين بقراط ستماية سنة فقط ، واذا حسبنا ما بيننا وبين كل واحد منهما وجدنا تاريخ الاسكندر الى وقتنا هذا ، وهو سنة ست وثلثين واربع للهجرة ، الف وثلثماية واثنين وستين سنة تامة زدنا عليها ماية وسبعة وعشرين سنة بين وفاة ارطخسست وبين وفاة الاسكندر فيكون ما بيننا وبين ابقراط الف واربعماية وتسعة وثمانون سنة ، واذا نقّصنا من تاريخ الاسكندر الاربعماية والثلاث والستين سنة ، كان بيننا وبين جالينوس تسع ماية سنة بعشرات سنين واحاد لان جالينوس يقول في كتابه في فهرست كتبه ان انطليوس اشخصه معه من بلده اليه وقد جاوز سبعة وثلثون سنة بمقدار قليل قد يمكن تصحيحه فقد تبين بما ذكرت ان منه هاؤلاي الحكماء .

فلنعود الان الى غرضنا في هذه المقالة وهو ان نبين كيفية التطرق بالطب الى السعادة .

٤٣ — Jean le Grammairien — احد علماء مدرسة الاسكندرية ، عاصر الفتح العربي . وهو احد الذين شاركوا في انتقاء ووضع الكتب الستة عشر لجالينوس .

الباب الثالث

في التطرق بالطب الى السعادة

قال علي : قد بينا فيما سلف ان صناعة الطب يمكن ان تتعلم في ثلاث سنين ، وانه لا حاجة بالطبيب الى غير كتب بقراط وجالينوس وكتاب دياسقوريدس ولذلك اقول : ان التشاغل بغير هذه الكتب كما قال بعض الناس دار حمى للاشقياء المحرومين المكدودين الذين لهم الى الخير المحض سبيل فيعدوه وقد تبين ان الطبيب يمكنه ان يفعل الخير ويصطنع المعروف الى الناس في حفظ صحة ابدانهم وشفـاء امراضهم حـتى يقوموا الى اشغالهم .

وقد قال جالينوس في آخر المقالة الاولى من حيلة البرء : وينبغي لنا ان ننافس ونباهي الملائكة في فعل الخير فانه لا شيء اقبح ولا اشنع من ان يقدر على فعل الخير فيتوانا عنه ويطرحه . وحكا عن اوديسوس في مقالته في تعرف الانسان عيوب نفسه : يا لك من امر ما اقبحه وازدراه ان تعرف الخير ولا تعمل به ، وقال ارسطوطاليس : ليس التواني عن العناية بالخير شر . وكان الاسكندر يقول : مما اجدته عن معلمي ارسطوطاليس اني لا اعد ملكي يوما لم افعل فيه خيراً ولم احسن فيه الى انسان ، وظاهر ان الطبيب الماهر اذا قصد الاحسان الى الناس فلا بد ان يحصل له منهم ما يكفيه في الضرورة وزيادة عليه .

قال بقراط : انه ليس في الدنيا شيء يفي باجرة الطبيب اذا كانت الصحة لا عيش الا بها ، ولا يتم شيء من الافعال الا بها ، والخلاص من المرض انما هو الخلاص من الموت ، فلذلك لا يفي شيء وان كثر باجرة الطبيب ، لكن اجره على الله عز وجل ، وما حصل له فينبغي ان يكون على وجه الهدية والصلة ، فاما غير ذلك واذا كان يمكنك فمن البين ان الطبيب يتوصل الى الكفاية في الضرورى ، والى الاحسان الى الناس وفعل الخير . ولما اجتمع بقراط مع دمقراط في ابديرا المدينة ضحك دمقراط ضحكا افرط فيه فسأله بقراط عن السبب المضحك له فقال دمقراط بهذا اللفظ : اخرجني يا بقراط الى الضحك طول التعجب مما ارى عليه امور الناس واحوالهم التي انا اشرحها لك لانهم

يفنون اعمارهم فيما لا يعود عليهم بمنفعة زمانهم مما يجب ان يهتزأ به ويضحك منه فمنهم من يجول اقطار الارض ويتعب نفسه ويشقيها ويذلّها حرصاً على اقتناء الذهب والفضة فاذا حصلا له مات وتركهما ، ولم ينتفع منهما بشيء . ومنهم من يشتري الخيل والدواب والضياع والارضين الواسعة ويعمرها ويغرس فيها الاشجار ويجعلها ملكا خاصا له وهو لا يقدر يملك نفسه ، ما هذا الحرص الفارغ الذي لا فرق بينه وبين الكبنون ، اذا افادوا المال زاد واشترى الارضين واذا اشتروها باعوا غلاتها وثمارها وجمعوا مالها . فكم في السرة يتقلبون ، اذا لم يكن لهم ثروة تأسفوا واغتمّوا ، واذا اثروا ستروا مالهم وغطوه ، وخافوا وقوع الحيلة عليهم فيه . ، قد شقيت نجوتهم ، وتخطوا نواميس الحق لمحبتهم للمعاملة فبعضهم يعادي بعضا ، وفيهم من يقاتل اخوانه واولاد بيته ، وبني مدينته بسبب اغراض الدنيا التي اذا مات نزلها ولم يكن مالكا لها ، فلم اعزل يا بقراط على ضحكي الا ترى ان السكارى اذا اختلطت عقولهم ، ضحك عليهم ، والعشاق تضحك منهم وليس بهم من المرض اكثر مما وصفناه . فالرؤساء يقولون الحظ والسعادة للعامة ، والعامة تشتهي الرياسة والمدبر للمدينة ان الصناع بايديهم اسعد واحمد عاقبة ، والصناع يغبطون المدبر للمدينة .

قال ابقراط : قلت الحق يا دمقراط واقسم بالله انك لسعيد لما ربحت من هذا السلوان (٤٤) .

قال علي : وقد بيّن ارسطوطاليس ان السعادة هي الحياة بالعقل وان العمر الطيب(٤٥) اللذيذ هو العمر مع العقل ، اذ ليس احد يختار الحياة وعقله عقل صبي . ومن عقول الصبيان التماس الشهوات البهيمية . وبين ايضا فيما بعد الطبيعة ان التمتع بالشهوات وبلوغ الاماني منها انما هي ادراكات ملذة . ومن كان حظه من هـذه الادراكات ٤ و
الملذة اكثر ، كان مغبوطا بما له اكثر ولذلك يكون ان من كان اكثر ادراكا للامور العظيمة ، فهو اوفر سعادة واكثر حظا ولذلك صار الحيوان افضل من النبات وذلك انه اكثر ادراكا من قبل انه حيوان حكيم له يدان يبطش بهما وعقل يفكر فيه ويتروّى ويتعلم ، ويستعمل الكلام ، والمخاطبات ، ويجد اصناف الاطعمة اللذيذة ، والنبات

٤٤ – في الاصل – السلسون   ٤٥ – في الاصل – الطبيب .

الرفيعة والنعم الحسنة ، والالوان المنوعة [٤٦] ويلتذ بما يشاهد من رؤية السماء بالكواكب ورؤية الارض بالمياه والانهار ، ومطبوع على حب الرياسة وتتوق نفسه الى معرفة اسباب ما يشاهد من الاشياء ومكمل بما ادرك من ذلك . ويتوق غيره بحسب ما يفضل عليه في الادراك ويصير افضل منه ، وهو ممن عرف عنايته الى الريادة في الفهم والمعرفة ، وان كان افضل ممن لم يتزايد يظن ان حظه من امور الدنيا اقل من حظ غيره من على (. . . .) [٤٧] بهـــا وذلك لثلاثة اوجه احدها ان فضائل الا بادخار [٤٨] جياد للابناء والثاني البحث الحادث عـــن عطايا النجوم في المواليد ، والثالث ان يعرض لمـــن انصرف الى النظر في اللذة بما يدركه من كبر النفس ، ما يشغله عن الأكتساب . والخضوع الى من هو دونه في الفهم . وحل هذا الشك سهل لانه لا يفوته وجود الضروري والحظوظ مراد للادراكات اللذيذة ، ولا شيء من الادراكات اللذيذة ولا اجلّ ولا افضل من ادراكات النظر الفلسفي ، وكلما كان ادراك الانسان افضل واسعد على الحقيقة . وافضل الادراكات واوفقها يقينا وصحة هي الادراكات الفلسفية اعني النظر في الحكمة واستعمال العدل والسخاء والعفة في نفقات المال . فاذن : السعادة الانسانية على اليقين والصحة هي التفلسف علما وعملا ولقد رأينا من على ذلك الطبيب اذا انصرف بعض يومه في رياضة بدنه في اعمال الطب وصرف ما في يومه في العمل الصالح والفكر في ملكوت السماوات والارض ، وعبد الله واطاع العقل وذلك ما اردنا بيانه .

تمت مقالة علي بن رضوان في التطرق بالطب الى السعادة . والحمد لله وصلى الله على سيدنا محمد واله اجمعين . نقلت ذلك جميعه من نسخة دقيقة الخط الى غاية ما يكون ما يعرف منه اول الحرف من اخر الا بفتح من الله سبحانه وتعالى ، بعبارات غريبة بعيدة عن القصد والتحير في اختصارها او اصلاحها ، ولطف الله جل وعلا بحسب ما امكن من القدرة . ونرجو من كرم الله تصحيحها ان شاء الله تعالى وهو حسبنا ونعم الوكيل . نقل عبيد الله سلمان ابن الاسعد المتطبب عفا الله عنهما . في شهور سنة نور عشر وثمانماية [٤٩] ، احسن الله عاقبتها .

٤٦ – في الاصل – الموقعة ٤٧ – كلمة غير مقرؤة ٤٨ – في الاصل – بادخاير .
٤٩ – ١٤٠٧ م .

ملخصات الأبحاث المنشورة في القسم الأجنبي

مسألة هندسية وحسابية لشرف الدين الطوسي

رشدي راشد

لقد بيّنا في دراسات سابقة أهمية أعمال شرف الدين الطوسي الرياضية ، وهذه الأعمال هي :

١ — كتابه « في المعادلات » الذي يمثل خطوة أساسية في تاريخ الجبر ونجد فيه بذور ما سيسمى من بعد بالهندسة التحليلية .

٢ — رسالته « في الخطين اللذين يقربان ولا يلتقيان » ، وهذه الرسالة هي أحد أشكال الكتاب السابق ومن ثم لا يمكن اعتبارها كعمل منفصل .

٣ — جواب على سؤال سأله أمير المدرسة النظامية ببغداد ، وهذه الرسالة هي موضوع مقالنا هذا وهي آخر عمل رياضي نعرفه لشرف الدين الطوسي وموضوعها : قسمة مربع معلوم إلى مستطيل وثلاثة منحرفات على نسبة معلومة .

فمن البين إذاً أن هذه الرسالة تهدف إلى بناء شكل هندسي يحقق علاقات عددية معينة بالمسطرة والبرجل ، واتبع الطوسي فيها طريق التركيب مخافة التطويل ، ولكن هذا الطريق وحده لا يفسر لنا اختيار الطوسي للقيم العددية المتعددة ولا للأبنية التي يقوم بها لتسلسل عرض تلك الأبنية . فإذا رجعنا إلى مفاهيم الطوسي ووسائله كما نعرفها من

كتابه « في المعادلات » لادراك وتحديد التحليل المستتر وراء التركيب يلزمنا افتراض ترجمتين : الأولى ترجمة جبرية للمسألة الهندسية تنتهي الى معادلة جبرية ، الثانية ترجمة هندسية للمسألة الجبرية هدفها الرد على السؤال المفروض بالبناء الهندسي . وهاتان الترجمتان تعبران عن علاقات جديدة بين الجبر والهندسة وعن تصور مختلف للمشكلة التقليدية أعني مشكلة التحليل والتركيب منذ كتاب عمر الخيام في الجبر والمقابلة ورسالته في قسمة ربع دائرة على شروط مفروضة . ومن الجدير بالملاحظة أن الجبريين لا يهملون الوصول الى نتائج حسابية محددة ، كما يشهد بذلك رسالة الخيام ورسالة الطوسي التي نحن بصددها .

فأهمية مسألة الطوسي تعود إلى طريقة الحل وعما تعبر عنه من تصور للعلاقات التي ذكرناها ولا ترجع الى صعوبة المسألة ولا إلى ندرة هذا النوع من المسائل ، فمن المعروف أن هذا النوع لم يكن نادراً قبل الخيام والطوسي من بعده بل قد توصل الرياضيون إلى حلول مسائل أكثر صعوبة أي تلك التي لا يمكن عملها بالمسطرة والبرجل كتقسيم الزاوية إلى ثلاثة أقسام متساوية وغيرها من المسائل الهندسية التي تستلزم قطوع المخروطات .

ملاحظات حول كتاب المفروضات لأقاطن

دولد - سامبلونيوس

لقد عالجت المؤلفة رسالة المفروضات لأقاطن بالتفصيل في أطروحتها للدكتوراه (أمستردام – ١٩٧٧) . وهي موجودة في نسختين تعودان للقرن الثالث عشر . احداهما والتي تحمل عنوان كتاب المفروضات لأقاطن موجودة في مخطوطة أيا صوفيا رقم ٤٨٣٠,٥ في استانبول (٨٩ ظ – ١٠٢ ظ) . وتتألف من ٤٣ فرضية في الهندسة المستوية . وهناك ١٩ فرضية من النصف الأول تشكل رسالة منفصلة تحت عنوان كتاب أرشميدس في الأصول الهندسية . وهي موجودة في مخطوطة بانكيبور رقم ٢٤٦٨,٢٩ (١٤١ و – ١٤٤ ظ) . وقد نشر مكتب المنشورات الشرقية العثمانية (حيدر أباد – دكن ١٩٤٧) نسخة عربية لهذه المخطوطة مع مخطوطة بانكيبور رقم ٢٤٦٨,٢٨ (١٣٤ ظ – ١٤١ و

كتاب أرشميدس في الدوائر المتماسة) . وقد تم ذكر أسباب قبول عنوان كتاب المفروضات وأقاطن مؤلفاً له في الفصل الثاني من الأطروحة .

وقد أضيف لعنوان مخطوطة بانكيبور ما يلي : « ترجم ثابت بن قرة الرسالة من اللغة اليونانية إلى اللغة العربية ». وسنعتمد على الحدس والتوقع في معرفة العنوان اليوناني الأصلي للرسالة والأسم الذي كان يُطلق على أقاطن في اليونانية.إن فعل فرض ربما يقابل في اليونانية فعل (ὑποτίθισθαι) أو بمعنى خاص يمكن أن يقابل (συγχωρέω) وعلى هذا الأساس فإن كلمة مفروضات هي ترجمة لكلمة (συγχώρησεις) أو كما في الحالة السابقة (ὑπόθεσεις) . وليس للمؤلف علم بوجود أية إشارة إلى رسالة يونانية تحمل أياً من العنوانين . وفي حالة اسم المؤلف فقد أقترح الفارسية (بهلوية) كواسطة بين الاسم اليوناني والاسم العربي . وبهذا يمكننا الوصول إلى الأسم اليوناني الأكثر شيوعاً (Ἀγάθων) . ولكنه لم يتم ذكر أي رياضي بهذا الاسم .

وتتضمن الرسالة (الأطروحة – الفصل الثالث) فرضيات جديرة بالاهتمام ، لكن دون وجود نظريات ذات شأن كبير . وتعالج بعض الفرضيات الخواص الأساسية للمثلثات وبعضها يدخل في نطاق علم المثلثات والأخرى تتصل بعلم البصريات . ومن خلال دراسة العلاقة بين رسالتنا ومجموعات ببوس فإنه ربما كان أقاطن أحد معاصري ببوس . ويمكن ملاحظة تأثيرات مختلفة على الرسالة (الاطروحة – الفصل الرابع) . والمكان الوحيد الذي له علاقة مباشرة بالرضيات العربيةهو في رسالة ابن الهيثم «في خواص المثلث من جهة العمود » . وفيها يبرهن ابن الهيثم على تقابل الفرضيات ٨ – ١٠ « إن مجموع الأعمدة في مثلث متساوي الأضلاع مرسوم من نقطة داخلية إلى الأضلاع الثلاثة يساوي ارتفاع المثلث » . فهو يبرهن على ذلك أولاً في حالة مثلث متساوي الساقين وثانياً في حالة مثلث متساوي الأضلاع . وعلى أية حال إن هذا التعميم ليس صحيحاً . ولا زالت رسالة أقاطن تحتفظ بقيمتها وأهميتها بالنسبة لعلماء الرياضيات العرب في القرن الثالث عشر كما هو واضح من الملاحظات الهامشية العديدة .

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كناش في الطب العربي من القرون الوسطى : كتاب المئة لأبي سهل المسيحي

غادة الكرمي

أُلّفت في اللغة العربية كتب طبية شاملة وعديدة بعد عام ٢٠٠ للهجرة . وكانت هذه الكتب تعرف باسم « كُنّاشات » . ويشير هذا الاسم إلى نوع معين من الكتب الطبية التي كانت تتضمن جميع المعلومات الاساسية بشكل مختصر حول الممارسات والنظريات الطبية في ذلك الوقت . وكلمة « كُنّاش » ليست عربية بل هي مشتقة من الكلمة السريانية « كُنّاشه » وتعني مجموعة . وأصبح « الكُنّاش » على مرّ الزمن أكثر الكتب انتشاراً التي كان يستخدمها الطبيب وطالب الطب على حد سواء .

ان « كتاب المئة » لأبي سهل المسيحي كناش نموذجي يعود للقرن الرابع . والمسيحي طبيب عاش في بلاد الفرس وقد قيل إنه أحد معلمي ابن سينا . توفي أبو سهل حوالي ٤٠١ — ١٠١٠ ، وقد ألف كتباً عديدة في الطب والمنطق والفلسفة . ولكن أشهر كتبه هو « كتاب المئة » . ولا يزال هذا الكتاب موجوداً فيما لا يقل عن ٢٩ مخطوطة تم نسخها في فترة امتدت منذ القرن الخامس حتى أواخر القرن الماضي . وكان كُنّاش المسيحي يتمتع بقيمة عظيمة أيام ظهوره وفيما بعد . ولكنه لم يترجم أبداً إلى اللغة اللاتينية في العصور الوسطى كما حدث لمؤلفات طبية عربية كثيرة .

يقدم هذا البحث نبذة عن حياة أبي سهل المسيحي ووصفاً لمحتويات كُنّاشه . وتورد المؤلفة مقتطفات من النص العربي مع ترجمة انكليزية لها . ولم يتم تحقيق هذا الكتاب حتى الآن . ومادة البحث مستقاة من مخطوطات لهذا الكتاب . وتتعرض المؤلفة لمكانة وأهمية هذا الكُنّاش وتبحث في الاسباب التي أدت الى عدم ترجمة هذا الكتاب الى اللغة اللاتينية خلال القرون الوسطى .

تقرير عن مخطوطة هامة للجزري

دونالد هيل

يصف هذا البحث مخطوطة رائعة من كتاب الجزري في الآلات . وقد نشر المؤلف ترجمة انكليزية لهذا الكتاب وستصدر قريباً نسخة عربية قام بتحقيقها الدكتور أحمد يوسف الحسن (معهد التراث العلمي العربي — حلب) . وكان يُعتقد سابقاً أن هذه المخطوطة قد تشتتت كلها ، بالرغم من أنه قد تم الإشارة إلى وجود عدد من الأشكال في مجموعات عامة وخاصة . على أن ٧٠ ٪ من المخطوطة الكاملة قد عرض للبيع من قبل شركة سوثبيز في لندن في الرابع من نيسان ١٩٧٨ واشترتها شركة سبينك في لندن أيضاً لقاء أكثر من ١٦٠,٠٠٠ جنيه استرليني . ويعبر المؤلف عن امتنانه لهاتين الشركتين لتعاونهما معه ولتزويده بصور فوتوغرافية ولسماحهما بنشر هذا البحث .

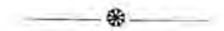
لقد كتبت المخطوطة على ورق مصقول سميك ، قياس كل صفحة ٢١٩ × ٣١٤ مم بخط نسخي جميل جداً . وتحوي كل صفحة ٢١ سطراً. ويشير حرد المتن (الكولوفون) الموجود في الصفحة الأخيرة إلى اسم الناسخ (فرخ بن عبد اللطيف) وإلى تاريخ هذه النسخة (٧١٥ ﻫ / ١٣١٥ م) . ويعتقد أنه قد تم اعداد هذه النسخة إما في سورية أو في مصر . وتأتي هذه النسخة في المرتبة الثالثة من حيث قدمها . وهي أجملها بالرغم من أنها ناقصة .

ويقدم البحث على شكل جداول تحليلاً كاملاً للمحتويات المتبقية من المخطوطة بمقارنتها مع المحتويات الكاملة المعروفة سابقاً من مخطوطات أخرى . ومن الأبواب الخمسين الأصلية هناك ١٤ باباً كاملاً مع الأشكال . ويوجد الآن ١٠٦$\frac{1}{2}$ أشكال صغيرة ورسوماً توضيحية من أصل ١٧٣ . ويوجد منها ١٩$\frac{1}{2}$ شكلاً رئيسياً . وقد تم نشر سبعة أشكال ملونة من المخطوطة في البحث المنشور في قسم الأبحاث الأجنبية من هذا العدد . وهي تتضمن فوارتين ورأس فوارة وآلة موسيقية آلية وثلاثة أشكال للمضخة المكبسية (ذات الاسطوانتين المتقابلتين) والمعروفة جداً للباحثين .

علم الفلك الاسلامي في اللغة السنسكريتية

دافيد بنجــري

يقوم هذا البحث بدراسة انتشار علم الفلك الاسلامي في الهند عبر قرون عديدة . ويدرس أيضاً ردود الأفعال المختلفة للعلماء الهنود تجاه الطرق والنتائج التي مارسها زملاؤهم المسلمين . ويركز البحث بشكل خاص على قضية فشل هذا النقل في احداث تغيير هام في علم الفلك الهندي . ويرى المؤلف أن حلاً جزئياً لتلك القضية يكمن في عدم تفهم الهنود لمنهجية علم الفلك عند المسلمين .



الساعة الشمسية التي وجدت في جامع ابن طولون في القاهرة

دافيد كينج واويس جنان

إن آثار الساعة الشمسية الرائعة التي كانت قبل كسرها تزين جامع ابن طولون في القاهرة منذ سنة ٦٩٦ هجرية وتفيد زوار الجامع بالوقت الماضي من شروق الشمس والباقي إلى غروبها كما وكانت تبين لهم وقت ابتداء صلاة الظهر والعصر قد اختفت أثناء البحوث التي اجريت عليها على أيدي المستشرقين الفرنسيين المنتمين إلى بعثة نابليون في أوائل القرن التاسع عشر . ولحسن الحظ لم تختف الساعة إلا بعد أن رسمها أحد أعضاء البعثة رسماً دقيقاً . وقد بحث المؤلفان في هذا الرسم من جديد لكي يحللا الخطوط المختلفة التي توجد على وجه الساعة كما بحثا في الجداول التي استخدمها الفلكيون في العصر المملوكي ليخططوا ساعات من هذا النوع .

ثلاث ساعات شمسية من الاندلس

دافيد كينج

توجد في متاحف اسبانيا ثلاث ساعات شمسية يرجع عهدها الى العصر الاسلامي في الاندلس . وقد بحث المؤلف في رسومها المختلفة التي ترتبط بالساعات الزمانية من النهار وبوقتي صلاة الظهر والعصر . ومع أن إحدى هذه الساعات من صناعة أحد الفلكيين المشهورين من الاندلس في أواخر القرن الرابع الهجري الا أنه يوجد في تخطيطها بعض الأخطاء . اما الساعتان الأخريان فصناعتهما تقريبية وقد حاول المؤلف أن يكتشف طريقة رسمهما . ويظهر من البحث أن صناعة الساعات الشمسية في الاندلس لم تكن على مستوى صناعتها في الشرق الاسلامي كما امكننا تصوره من الرسائل المؤلفة في موضوع تخطيط الساعات في العصر العباسي .

المشاركون في العدد

عادل أنبوبا : يبحث في تاريخ الجبر والهندسة . درّس تاريخ العلوم عند العرب والرياضيات في الجامعة اللبنانية وفي الكلية الفرنسية للعلوم الاقتصادية في بيروت . تضم منشوراته دراسات عن الكرجي والشجاع بن أسلم والسموءل وآخرين من علماء الرياضيات العرب .

دافيد بنجري : أستاذ في قسم تاريخ الرياضيات بجامعة براون . يتقن استخدام المصادر السنسكريتية والعربية واللاتينية واليونانية . وله اهتمام خاص في تاريخ علم التنجيم .

جاري تي : محاضر في جامعة أوكلاند ، نيوزلندا ، قسم الرياضيات . يعمل بشكل أساسي في التحليل العددي والحساب بالإضافة إلى تاريخ العلوم .

لويس جنان : دكتور في الحقوق . تقاعد من عمله في بنوك عدد من الدول العربية . وهذا ما جعله يهتم بتاريخ العلوم عند العرب وبشكل خاص في نظرية الساعات الشمسية في العصرين الوسيط والحديث .

سامي حمارنه : باحث في المتحف القومي للتاريخ والتكنولوجيا ، معهد سميثسونيان ، واشنطن . مؤرخ في الطب والصيدلة عند العرب . له كتب ومقالات عديدة في هذا المجال منها : « أصل الصيدلة والعلاج في الشرق الأدنى » و « ابن القف الطبيب والمعالج والجرّاح » .

ايفون دولد ـ سامبلونيوس : تدرّس حالياً تاريخ الرياضيات عند العرب في جامعة هيدلبرغ . لها منشورات في تاريخ الهندسة عند العرب ، وتعمل الآن في كتاب المفروضات لثابت بن قره .

رشدي راشد : أستاذ بتاريخ العلوم في المركز القومي الفرنسي للبحوث الفرنسية للعلوم وبمعهد تاريخ العلوم بجامعة باريس ا . تتضمن منشوراته دراسات في تاريخ الجبر والهندسة .

سلمان قطايه : أستاذ أمراض الأذن والأنف والحنجرة في كلية الطب بجامعة حلب . له مؤلفات وأبحاث عدة في تاريخ الطب .

غادة الكرمي : طبيبة ومؤرخة في الطب العربي . تقوم الآن بدراسات وأبحاث في تاريخ الطب عند العرب في معهد التراث العلمي العربي بجامعة حلب .

ادوارد س. كنلدي : استاذ سابق في الجامعة الامريكية في بيروت واستاذ باحث حالياً في معهد التراث العلمي العربي بحلب. له ابحاث وكتب عديدة في تاريخ الفلك والرياضيات عند العرب والمسلمين.

دافيد كينج : يعنى بشكل أساسي في علم الفلك والرياضيات عند المسلمين في العصر الوسيط . يعمل الآن في مركز البحوث الأمريكي بالقاهرة . له منشورات عديدة في علم الميقات .

دونالد هيل : يزاول عمله كمهندس . ويبحث في تاريخ التكنولوجيا العربية . ترجم كتاب الجزري الى الانكليزية ويقوم حالياً باكمال تحقيق مخطوطات بني موسى .

ملاحظات لمن يرغب الكتابة في المجلة

١ – تقديم نسختين من كل بحث أو مقال الى معهد التراث العلمي العربي . طبع النص على الآلة الكاتبة مع ترك فراغ مزدوج بين الاسطر وهوامش كبيرة لأنه يمكن أن تجرى بعض التصحيحات على النص ، ومن أجل توجيه تعليمات الى عمال المطبعة . والرجاء ارسال ملخص يتراوح بين ٣٠٠ – ٧٠٠ كلمة باللغة الانكليزية إذا كان ذلك ممكناً وإلا باللغة العربية .

٢ – طبع الحواشي المتعلقة بتصنيف المؤلفات بشكل منفصل وتبعا للارقام المشار اليها في النص . مع ترك فراغ مزدوج أيضا . وكتابة الحاشية بالتفصيل ودون أدنى اختصار .

أ – بالنسبة للكتب يجب أن تحتوي الحاشية على اسم المؤلف والعنوان الكامل للكتاب والناشر والمكان والتاريخ ورقم الجزء وأرقام الصفحات التي تم الاقتباس منها .

ب – أما بالنسبة للمجلات فيجب ذكر اسم المؤلف وعنوان المقالة بين أقواس صغيرة واسم المجلة ورقم المجلد والسنة والصفحات المقتبس منها .

ج – أما إذا أشير الى الكتاب أو المجلة مرة ثانية بعد الاقتباس الأول فيجب ذكر اسم المؤلف واختصار لعنوان الكتاب أو عنوان المقالة بالاضافة الى أرقام الصفحات.

أمثلة :

أ – المطهر بن طاهر المقدسي ، كتاب البدء والتاريخ ، نشر كلمان هوار . باريس ١٩٠٣ ، ج ٣ ، ص ١١ .

ب – عادل انبوبا ، « قضية هندسية ومهندسون في القرن الرابع الهجري ، تسبيع الدائرة » ، مجلة تاريخ العلوم العربية. مجلد ١ ، العدد الثاني : ١٩٧٧ ص ٧٣.

ج – المقدسي ، كتاب البدء والتاريخ ، ص ١١١ .
انبوبا ، « قضية هندسية » ، ص ٧٤ .

منشورات معهد التراث العلمي العربي

صـــدر حديثـا النص العربي الـكامل لـكتاب الجـزري



تحقيق الدكتور أحمد يوسف الحسن

هذا الكتاب مرجع لا غنى عنه لمؤرخي التكنولوجيا والعلوم · انه النص العربي الكامل الذي يتجاوز ٥٠٠ صفحة والذي تم تحقيقه بالرجوع الى أفضل مخطوطات الكتاب المعروفة في الوقت الحاضر · وقد تم اعداد ورسم ١٧٥ رسما بعـد دراسة دقيقة وبشكل مطابق للرسوم الاصلية · ويبحث الـكتاب في مختلف أنواع الآلات الميكانيكية والهيدروليكية العربية التي تبين الابـداع العربي في مجال الهندسة الميكانيكية في القرن الثاني عشر/الثالث عشر الميلادي ويحتوي الكتاب على فهرس شامل للمصطلحات الفنية مع معجم للمصطلحات بالانكليزية والعربية ، مما يضفي على الكتابّ قيمة كبيرة ·

تحت رعاية السيد رئيس الجمهورية

الندوة العالمية الثانية لتاريخ العلوم عند العرب

٥ ــ ١٢ نيسان ١٩٧٩

التسجيل طوال ٤ نيسان

حلقات البحث :

١ ــ تاريخ الجبر العربي
٢ ــ مكانة الثقافة العلمية في الحضارة الاسلامية
٣ ــ انتقال العلم العربي الى الغرب اللاتيني

الجلسات العلمية :

الطب
الزراعة والحيوان
فلسفة العلوم وانتقالها
العلوم الدقيقة (رياضيات ــ فلك ــ تنجيم ــ فيرياء)
الكون ــ الكيمياء ــ المغناطيسية ــ علوم الارض
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أبحاث عامة في تاريخ العلوم العربية



توجه المراسلات الى :

الآنسة أمل رفاعي ــ مكتب الرئيس ــ جامعة حلب

حلب ــ الجمهورية العربية السورية

مطبوعات
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بجامعة حلب

آ ـ الكتب :

١ ـ **أحمد يوسف الحسن** :تقي الدين والهندسة الميكانيكية العربية معكتاب الطرق السنية في الآلات الروحانية من القرن السادس عشر ١٩٧٦ ·
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٣ ـ **سلمان قطاية** : مخطوطات الطب والصيدلة في المكتبات العامة بحلب ١٩٧٦ ·
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٤ ـ **ادوارد كندي وعماد غانم** : ابن الشاطر فلكي عربي من القرن الثامن الهجري/الرابع الميلادي ـ ١٩٧٦ ·
٦ دولارات

٥ ـ **ادوارد س · كندي** : أفراد المقال في أمر الظلال للبيروني ·
جزء (١) : الترجمة الانكليزية ·
جزء (٢) : التعليق والشرح (بالانكليزية) ·
٢٥ دولاراً

٦ ـ **معهد التراث العلمي العربي** :أبحاث الندوة العالمية الاولى لتاريخ العلوم عند العرب (المنعقدة بجامعة حلب من ٥ ـ ١٢ نيسان ١٩٧٦)
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الجزء الثاني : الابحاث باللغات الاجنبية

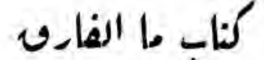
أبحاث المؤتمر الثاني (١٩٧٧) والثالث (١٩٧٨) للجمعية السورية لتاريخ العلوم . (تحت الطبع)

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١ ـ **مجلة تاريخ العلوم العربية** : دورية عالمية متخصصة تصدر مرتين كل عام · المجلد الاول (١٩٧٧) · المجلد الثاني (١٩٧٨) الاشتراك السنوي ٦ دولارات ·

٢ ـ **عاديات حلب** : حولية تبحث في تاريخ الحضارة والآثار والعلوم : العدد الاول (١٩٧٥) العدد الثاني (١٩٧٦) العدد الثالث (١٩٧٧) ٦ دولارات للعدد الواحد ·

٣ ـ **رسالة معهد التراث العلمي العربي** : نشرة دورية تصدر أربع مرات كل عام ·الاشتراك السنوي ٤ دولارات بالبريد العادي ، ٥ دولارات بالبريد الجوي ·



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(٢٥١ – ٣١٣ – ٩٢٥ / ٨٦٥)

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Examples :

O. Neugebauer, *A History of Ancient Mathematical Astronomy* (Springer, New York, 1976), p. 123.

Sevim Tekeli, "Taqī al-Dīn's Method of Finding the Solar Parameters", *Necaci Lugal Armagani*, 24 (1968), 707–710.

3. In the transliteration of words written in the Arabic alphabet the following system is recommended:

ʾ	a	b	t	th	j	ḥ	kh	d	dh	r	z	s	sh
ء	أ	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش

ṣ	ḍ	ṭ	ẓ	ʿ	gh	f	q	k	l	m	n	h	w	y
ص	ض	ط	ظ	ع	غ	ف	ق	ك	ل	م	ن	ه	و	ي

For short vowels, *a* for *fatḥa*, *i* for *kasra*, and *u* for the *ḍamma*.

For long vowels the following diacritical marks are drawn over the letters *ā*, *ī*, *ū*.

The diphthong *aw* is used for أو and *ay* for أي .

NOTES ON CONTRIBUTORS

Adel Anbouba, works on the history of algebra and geometry. He has taught the history of Arabic science and mathematics at the Lebanese University and at the French Faculty of Economics in Beirut. His publications include studies on al-Karajī, Shujāʿ b. Aslam, al-Samaw'al, and other Islamic mathematicians.

Yvonne Dold-Samplonius, presently teaches the history of Arabic mathematics at the University of Heidelberg. She has published studies on the history of Arabic geometry and is currently working on Thābit b. Qurra's *Kitāb al-mafrūḍāt*.

Sami K. Hamarneh, of the Smithonian Institution's National Museum of History and Technology, is a historian of Arabic medicine and pharmacy. He is the author of several books and articles on these subjects, including *Origins of Pharmacy and Therapy in the Near East*, and *The Physician, Therapist, and Surgeon, Ibn al-Quff*.

Donald Hill, is a practising engineer whose avocation is the history of Arabic technology. He has published an English translation of the treatise of al-Jazarī, and is currently completing an edition of manuscripts of the Banū Mūsā.

The editors have just learned with sadness of the sudden death of **Louis Janin**, *docteur en droit*. He had retired some time ago from a banking career which included residence in various Arabic-speaking countries. This led to his interest in Arabic science, in particular medieval and modern gnomonics.

Ghada Karmi, is a physician and historian of Arabic medicine. She is engaged in research at the Institute for the History of Arabic Science.

Salman Kataye, is Professor of Otorhynolaryngology at the Faculty of Medicine, University of Aleppo. He has published several works on the history of medicine.

E. S. Kennedy, sometime professor of mathematics at the American University of Beirut, is currently a research professor at the Institute for the History of Arabic Science. He has published several studies in the history of Arabic-Islamic science.

David A. King, whose professional interest is in the astronomy and mathematics of medieval Islam, is resident in Egypt. In particular, he has numerous publications in the field of astronomical timekeeping

David Pingree, is a professor in the History of Mathematics Department at Brown University. He controls the Sanskrit, Arabic, Latin, and Greek sources, and has a special interest in the history of astrology.

Roshdi Rashed, is director of research at the C. N. R. S. Institute for the History of Science, University of Paris. His publications include studies in the history of algebra and geometry.

Garry J. Tee, is a senior lecturer in the mathematics department of the University of Auckland. He works chiefly in the fields of numerical analysis and computing, but also in the history of science.

Summary of the Arabic Article in This Issue

A propos du discours "Fī'l-taṭarruq fi'l-ṭibb ilā al-saᶜāda" (Vers le bonheur par l'intermédiaire de la médicine de ᶜAli b. Riḍwān)

SALMAN KATAYE

Nous présentons pour la première fois, le texte complet du manuscrit *Maqāla fi'l-taṭarruq fi'l-ṭibb ilā al-saᶜāda* de ᶜAlī ibn Riḍwān. Ce texte, unique, est conservé jusqu'à présent dans la bibliothèque de Ḥakīm Uglū Bacha.

Ce discours revêt une certaine importance:

Il nous permet de déterminer la date de naissance de ᶜAlī ibn Riḍwān et de calculer son âge avec précision.

Nous pouvons relever dans ce même traité certaines évocations portant sur la conception qu'avait Ibn Riḍwān de l'enseignement médical. Il prétend qu'on peut étudier la médecine sans professeur. Ce qui lui a attiré beaucoup de critiques.

Dans *al-Taṭarruq*, il expose de nouveaux arguments rendant son point de vue plus acceptable.

La troisième partie de son discours est consacrée au développement du titre de ce dernier, il explique alors l'aspect philosophique de la pratique médicale. C'est une conception religieuse qui s'appuie sur l'idée que la médecine est un acte de charité et un moyen de satisfaire Dieu et mériter le paradis.

Enfin, dans ce même discours, Ibn Riḍwān aborde l'histoire de la médecine pré-islamique. Nous remarquons qu'Hippocrate et Galien sont, d'après lui, les seuls dignes d'être estimés et respectés, surtout Galien, dont les ouvrages sont, à son avis, d'une valeur incontestable, il s'en prend même durement à ceux qui l'ont critiqué, tel Rhazes.

science to mediaeval Europe. Although the two Dutch publishers are to be commended for publishing these two volumes, it might have been more appropriate for the entire text to have been published in the scholarly journal where it began to appear.

GARRY J. TEE

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H. L. L. Busard, *The Translation of the Elements of Euclid from the Arabic into Latin by Hermann of Carinthia (?), Books I-VI*. Leiden, E. J. Brill, 1968. 142 pages. (Books I-VI) 24 f.

H. L. L. Busard, *The Translation of the Elements of Euclid from the Arabic into Latin by Hermann of Carinthia (?), Books VII-XII*. Amsterdam, Mathematisch Centrum,1 977. 198 pages. Mathematical Centre Tracts 84

In 1271, Gerard d'Abbeville bequeathed to the Sorbonne a Latin manuscript, (Bibl. Nat. Latin 16646) of Euclid's *Elements*, Books 1 to 12, and that text has now been printed by Busard. Books 1 to 6 are contained in the 1968 volume (which is reprinted from *Janus*, 54, 1-2, (1967)), and Books 7 to 12 are contained in the 1977 volume – Books 7 to 9 had first been printed in *Janus* (59, (1972), 125-187). The manuscript does not contain Euclid's Book 13, on the regular polyhedra.

The Latin text is obviously translated from Arabic, and there is some tenuous evidence suggesting that the translator might have been Hermann of Carinthia (*fl.* 1143). Hermann is known mainly as the translator from Arabic into Latin of Ptolemy's *Planisphere* (which has survived solely through his translation), and as co-translator with Robertus Ketenensis of the *Koran*.

This Latin translation of Euclid appears to be intermediate in time between the 3 versions ascribed to Adelard of Bath (*fl.* 1116-1142), and the version ascribed to Campanus of Novara (c 1205-1296), which was used for the first printed edition of Euclid.

It is approximately contemporary with Gerard (c1114-1187) of Cremona's translation, which includes the pseudo-Euclidean Books 14 and 15. Campanus made use of the versions by Adelard, but Busard considers that this version by Hermann (?) was not used by Campanus.

Busard analyses and compares the several known Arabic and Latin texts of Euclid, in order to determine which Arabic version was used as the source of this text. In the 1968 volume, after an analysis of Books 1 to 6 he considers that it was translated from Thābit ibn Qurra's revision of the translation by Isḥāq ibn Ḥunayn. However, in the 1977 volume, after analysing the full text, he considers it more likely to have been translated from the very first Arabic version of Euclid, the translation made by al-Ḥajjāj ibn Yūsuf ibn Maṭar under the patronage of Hārūn al-Rashīd.

This Latin text cannot have had much influence on the development of geometry, since no other manuscript of it is known; but it is of some interest for the evidence which it presents concerning the transmission of Arabic

from a manuscript (in Uppsala) in which the work is attributed to al-Fārābī (who died in 339/950). In fact, in a later book (A.K. Kubesov, *Matematicheskoye naslediye al-Fārābi*, "The Mathematical Heritage of al-Fārābī", in Russian, Izd. "NAUKA"Kaz. SSR, Alma-Ata, 1974), Kubesov explains pp. 52-53) that the manuscripts of the work *On Geometrical Constructions* incorporate almost the entire book *On Geometrical Figures* (written by al-Fārābī, according to the Uppsala manuscript), together with some additional material, presumably supplied by Abū'l-Wafā'. On p. 29, Toomer mentions citations of al-Fārābī's commentary on Ptolemy's *Almagest*. "Which does not appear to be extant". However, Kubesov (1974) devotes chapters 4 and 5 to analysing that commentary (from a manuscript in the British Museum), and the publication of a Russian translation of al-Fārābī's commentary on Ptolemy's *Almagest* was announced by B. A. Rozenfel'd on p. 109 of the first issue of this Journal.

Toomer's edition of Diocles is a valuable contribution to the history of Greek and Arabic science.

Note on the Text

Dr. N. Kanawati has examined the reproduced manuscript, and he informs me that Toomer has made a very accurate translation of the difficult non-mathematical introduction (sentences 1 to 37); except that in the opening invocation the phrase "grant long life" is much more likely to be "grant help", i. e. *aᶜin* instead of *aᶜmir*. The word *ḥattā* (= till, to, even), repeated in sentences 3 and 4 in the Arabic transcription, should certainly be rendered *matā* (= when). Compare these two instances with the way *ḥattā* is written in sentences 22, 24, 36 and 37. Curiously however, Toomer's translation in both cases is the correct one – "when". The emendation of the important corrupt name (in sentences 3 and 4) to "Zenodorus" is probable, but hardly "certain", as Toomer asserts.

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10-16 deal with the doubling of the cube. (Propositions 6 and 9 are trivialities, which Toomer considers plausibly to be spurious additions to Diocles' text.) Propositions 1, 4 and 10 contain the earliest known treatment of the focus and directrix of the parabola – the *Conics* of Apollonius treats the foci of ellipses and hyperbolae, but it is remarkable that none of his surviving writings mention the focus of the parabola.

The theory of conic sections was invented by Menaechmus (mid-4th century), who named the 3 types as the "section of an acute-angled cone", "section of a right-angled cone" and "section of an obtuse-angled cone"; whereas we use Apollonius' names of "ellipse", "parabola" and "hyperbola" respectively. Archimedes (killed in – 212) used Menaechmus' "cone" names, even though he effectively defined the curves by their equations in Cartesian coordinates, rectangular and even oblique. Diocles consistently calls the parabola a "section of a right-angled cone". Ellipses and hyperbolae occur only in his proposition 8, and there he uses their modern names, supposedly invented by his exact contemporary Apollonius. Could the *Conics* have been 'published' while Diocles was writing his book, inducing him to change his concept of the conic sections? Toomer suggests alternatively a modification of the accepted history of conic sections, according to which the names "ellipse" and "hyperbola" were invented together with the "coordinate" definition of the curves, and Apollonius standardized those names instead of inventing them.

Eutocius quoted Diocles' proposition 7, but he re-wrote propositions 8,10,11,12 and 13 to accord with the geometric style (Apollonian) regarded as orthodox in his day. In particular, as had been suspected by some previous investigators, the references to the *Conics* in Eutocius' version did not occur in Diocles' text. It is noteworthy that Diocles refers 4 times to a flexible strip of horn, used exactly like a modern draughtsman's spline for drawing a smooth curve through a set of points.

The 16 diagrams omitted from the manuscript have been restored most effectively by Toomer. Geometrical texts can permit such complete reconstructions of missing diagrams; an interesting contrast with, say, a biological text, where such a reconstruction would usually be impossible.

On p.23 Toomer refers to an elegant construction of a parabolic mirror with a given focal distance, which he ascribes to Abu'l-Wafa (mid 10th century), and which has been printed in French and in 2 Russian versions. Toomer notes that Krasnova's translation was made from a manuscript (in Istanbul) of Abū'l-Wafā's book *On Geometrical Constructions*, but that the translation by A. Kubesov (al-Fārābī, *Matematicheskiye traktaty*, "Mathematical Treatises", in Russian, Alma-Ata, 1972, pp.104-106), was made

book had been translated into Arabic, since Eutocius' extracts say nothing about burning mirrors (except in the title).

A few years ago Dr. Fuat Sezgin directed G. J. Toomer's attention to an Arabic manuscript of mathematical writings in the Shrine Library at Meshhed in Iran, including an Arabic version of Diocles' treatise *On Burning Mirrors*. That manuscript (dated A H. 867 = 1462/3) is a carelessly written version of an anonymous well-written translation of Diocles' work, and it is the only known manuscript of that work (apart from an inferior transcript of that Meshhed manuscript, now in Dublin). Blank spaces are left in the manuscript where the diagrams should have been inserted.

Toomer's admirable edition consists of Preface and Contents, then an Introduction (pp.1-33), the edited Arabic text with facing English translation (pp. 34-113), photographs of the entire Arabic manuscript of Diocles' treatise (pp.114-137), Commentary (pp.138-175), Appendix A with text and translation of Eutocius' excerpts (pp.177-201), Appendix B with other ancient and mediaeval proofs of the focal property of the parabola (pp.202-204), Appendix C (by Otto Neugebauer) on Archimedes' problem and Diocles' solution (pp.205-212) Appendix D (also by Neugebauer) on a non-standard parabolic mirror (pp.213-216), Bibliography (pp. 217-223), Index of Technical Terms in Arabic (pp.224-238) and a General Index (pp.239-249). The elegant printing of the Arabic text was generated by a computer; but it is amusing to observe that the 12 pages of Eutocius' Greek excerpts (with elaborate textual apparatus) are reproduced from handwriting, although Greek words and phrases are printed neatly in the Introduction. There can have been few mathematical books of recent times in which some footnotes have been written so casually in Greek.

One of the most important features of the Arabic text is that it enables Toomer to determine the date of Diocles. The 4th and 5th sentences associate Diocles (in Arcadia) with a person whose name is rendered corruptly, first as 'Byūḍām-s and then as'Ynūḍām-s: in view of the careless writing of the Meshhed manuscript these corruptions are emended by Toomer to Zīnūḍūrus, which corresponds to Zenodorus. Now, Zenodorus was a mathematician of the early -2nd century, best known from the fragments of his pioneering work on isoperimetric problems. Thus, Diocles appears to have been a close contemporary of Apollonius, the Great Geometer himself. This dating raises interesting questions about the chronology of the theory of conic sections.

Diocles' text contains 16 diverse propositions. Propositions 1, 4 and 5 deal with parabolic mirrors (including paraboloids of revolution), propositions 2 and 3 treat spherical mirrors, propositions 7 and 8 deal with a problem posed by Archimedes (expressible as a cubic equation), and propositions

as "social parasites", thrown out of society to meet their own fate. They inevitably sought ascetic living. And in their ascetic conditions and meditations they dreamed of rebirth for a happier rejuvenation. They tended to practice spiritual excercises and to utilize the herbo-metallic drugs of the Rasayana (p.117) to attain that end. But interestingly, the author comes out triumphantly and pointedly when he concludes by emphasizing his praiseworthy statement that "Indian medicine is unique in recognizing rejuvenation, and Indian philosophy is unique in aiming at immortality". (p. 118).

I must conclude by saying that here is an excellent literary contribution, a book deserving the attention of historians of science, cultural history, and the occult. It shows a link in the history of alchemy between countries and cultures in the East and in the West – a connection worth exloring and elucidating. It fills a gap in this new and dynamic topic by exploring the origins and development of alchemy, and the philosophy of this ancient "art".

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G. J. Toomer. *Diocles, On Burning Mirrors*, The Arabic Translation of the Lost Greek Original. Edited with English translation and commentary. Berlin-New York, Springer-Verlag, 1976. 249 p. Sources in the History of Mathematics and Physical Sciences. $27.90.

In the 6th century Eutocius (a friend of Anthemius) produced a valuable series of commentaries on ancient Greek mathematics, written perhaps at Alexandria. In his commentary on Archimedes' *Sphere and Cylinder II* he quoted passages from several earlier authors on the problem of doubling the cube, and in particular he quoted (or rather, he paraphrased) several pages from a treatise *On Burning Mirrors* by a certain Diocles, employing conic sections and also a special cubic curve for solving cubic equations. That commentary by Eutocius was translated together with the text of Archimedes into Arabic and then into Latin (first by William Moerbeke in 1269, translating from the Greek text), and later into many modern languages. They have been printed together in every major edition of Archimedes since the *editio princeps*, in 1544.

Much controversy has raged over the dating of Diocles, with various investigators suggesting dates from the 3rd century B.C. to the lst. The full Greek text of Diocles is lost, but in 1905 Eilhard Wiedemann drew attention to a 14th-century Arabic encyclopaedist's reference to Diocles having proved that burning mirrors should be paraboloidal; which suggested that Diocles'

Herbs were plentiful, easy to secure, and most convenient to gather and utilize. Soon the herbometallic drugs developed. Finding and compounding such "miracle drugs and panaceas" led to the belief in rejuvenation, and eventually to immortality – the final goal of Rasayana. Here enters, likewise, the philosophic-religious thinking and exercises – yoga.

This reviewer disagrees with the author in identifying such a process with the elixir (Arabic *iksīr*) of the Muslim alchemists. Basically, the *iksīr* (or the philosopher's stone) is considered to be that special element or compound that, once prepared and "isolated", when treated with lesser metals transforms them into silver and gold. This Islamic notion of alchemy based on Greek writings embodies the rational concept that elements are transformable from one condition to another, hence from one metal into a more honorable one under the right amount of pressure, temperature, and other natural forces and conditions. To the alchemist, this meant the application of fire and other techniques and "potent" ingredients including the elixir to speed up the work of nature. His chemicals, fire, drugs, and equipment achieve in a very short interval what might take nature a long time to attain.

Indian alchemists introduced instead, imaginary and possibly pagan religious and philosophical practices, exercises, and theories quite foreign to their Muslim counterparts. The Indian alchemist believed in resurrection of the body as explained in Christian teachings as well as in heathen mythology. Here it is believed that the perishable part of the human put on the imperishable nature, and the mortal that is capable of dying put on immortality, acquiring freedom from death. These constituted the true precepts of Indian alchemy as explained by the author.

In reviewing and examining several original Arabic alchemical treatises even those abounding with symbolism, this reviewer found that Muslim alchemists were primarily seekers of material riches. Religious and spiritual values and rewards were found there no more than in contemporary writings in the arts and sciences. More "piety" entered into later compilations as a cover-up for failure, or as a hypocritical cloak put on for protection, or as a ray of hope amid continuous disappointments in achieving what had been sought in vain. Much "spirituality" was perhaps to deceive or for self-deception. In the Arabic alchemical literature, *kīmiyā* is essentially an art, an honorable one (*ṣinā*ʿ*ah sharīfah*) by which material ends are attained and riches gained with high prestige. It was not primarily intended to promote imaginary spiritual values or ascetic dreams and religious aspirations.

In fact, one finds it difficult to appreciate the logic followed by the author in assuming the original theory for ascetic rejuvenation and immortality as the origin of alchemy. He states that senior citizens were looked upon

Book Reviews

S. Mahdihassan. *Indian Alchemy* or *Rasayana in the Light of Asceticism and Geriatrics*, New Delhi (India), Institute of History of Medicine and Medical Research, 1977. x + 139 pages, $5.00.

Here at last is a book on alchemy in India that departs from the traditional historical studies carried out in the West for the last two centuries. It makes for some of the finest reading on the subject. Although this reviewer disagrees with the author on many essential interpretations, this in no way minimizes the importance of a praiseworthy contribution to the history of alchemy.

For clarity and organization, Dr. Mahdihassan divides this brief text into over sixty chapters – a case of oversimplification. But the reader will greatly benefit from its objective, straightforward approach and thoroughness.

Following a foreword by Prof. S. H. Nasr, the author presents a very useful introduction summarizing his analysis of the topic and the discussions that follow. He also gives a select bibliography and seven previously published illustrations. In the discussions, he asseverates the antiquity of alchemy in India, associating its origin with yoga. He refers to this "art" as a living "cultural fossil", the product of alchemists who led a life of asceticism and sought geriatric treatment. He explains how human concepts and the application of asceticism changed man's belief from animism to dualism in a developed society realizing the creation process. Here the interpretation of how the two opposite sub-souls of male and female (the Yang and Yin of China and the Brahman and Atman of India) in their union led to immortality – the dream and goal of Rasayana. This, in the author's opinion, is the source of Indian alchemy defined by Patanjali as the Rasayana. It denotes health restoration, and with its specially prepared medications causes rejuvenation and makes one immortal. At this point, the author introduces the Indian deity, Shiva, who modified Rasayana and founded alchemy, which in turn modified him. The connection, however, seems the result of legendary traditions and folklore rather than a historical development. The insistence of the author upon defining the exact origin of alchemy, and upon naming its founders seems to be a well-nigh unattainable pursuit.

To interpret the appearance of Rasayana, the author skilfully describes the impact of two disciplines: medicine and philosophy, or rather, Indian philosophic-religious thinking. Since healthy living, virility, and longevity were the alchemist's primary objectives, medicine then entered the picture.

rabbinical text is placed between the two treatises written by Ibn Muᶜādh, namely *Kitāb majhūla* (fols. 49-74) and the *Maṭraḥ al-shuᶜāᶜāt* (fols. 76-81), it clearly refers to the *Kitāb al-asrār* (fols. 1-48) because it is the only one in which mechanical devices, corresponding to Isḥāq b. Sīd's allusions, are mentioned.

All this, of course, agrees with the fact that all the dates mentioned in the manuscript (until fol. 105) correspond to the reign of Alfonso X. We have, therefore, the only specimen remaining of a manuscript copied in his Toledan court. The link suggested by Hill, between the use of mercury as a source of power in one of the clocks described in the *Kitāb al-asrār* and in another one contained in the *Libros del saber de Astronomía*, becomes very probable.[4]

4. Furthermore the *Libro de las Armellas* quotes Ibn Muᶜādh's system for *taqwīm al-buyūt* in a way similar to Ibn Muᶜādh's in his *Maṭraḥ al-shuᶜāᶜāt* which, as we have seen, is found in the manuscript.

Note

The "World Directory of Historians of Mathematics", first published in 1972, has just appeared in a second, revised and much enlarged edition. Listed are about 1200 scholars who are devoting at least part of their time to teaching and/or research in the history of mathematics. Besides the current address, the main fields of interest of each person is given. Indexes by fields and by countries follow the alphabetical list.

Prepared by K. O. May (1915-1977) and Laura Roebuck, the new edition (iv + 92 pp.) may be ordered from the International Commission on the History of Mathematics, 11 Evergreen Gardens, Toronto, Ont. M4G 1C4, Canada. Price: $7.00 if payment is inclnded with order; $1.00 extra for postage on billing with shipment.

C. J. Scriba

NOTES AND CORRESPONDENCE

A Further Note on a Mechanical Treatise Contained in Codex Medicea Laurenziana Or. 152

MARIA VICTORIA VILLUENDAS*

The importance of the Codex Medicea Laurenziana Or. 152 has recently been emphasized by Drs. D. R. Hill[1] and A. I. Sabra.[2] I also have been acquainted with this manuscript since 1973, although at that time, I was mainly interested in another of the works contained in it: the *Kitāb majhulāt qisī al-kura* by Ibn Muᶜādh al-Jayyānī which was the main subject of my Ph. D. thesis.[3] Therefore I have a certain knowledge of the Ibn Muāᶜdh style which allows me to confirm Sabra's hypothesis; I do not think Ibn Muᶜādh can be considered the author of the *Kitāb al-asrār fī natā'ij al-afkār* and agree with Sabra concerning the name of the author (Aḥ)mad or (Muḥam)mad b. Khalaf al-Murādī. The *nisba* al-Murādī appears frequently in Ibn Ḥayyān's *Muqtabis* and in other Andalusian texts of the 10th and 11th centuries. He might, of course, be the Abu'l-Ḥasan ᶜAbd al-Raḥmān b. Khalaf b. ᶜAsākir mentioned by Ṣāᶜid of Toledo, as proposed by Sabra.

In the preliminary survey of the *Kitāb al-asrār* certain data contained in fol. 75 should be taken into consideration. In it there is a text written in Andalusian dialect, but in rabbinical Hebrew script. I have been able to read it thanks to the very valuable help of Professors Fernando Diaz, David Romano and Juan Vernet of Barcelona University. The text states that Isḥāq b. Sīd, the famous Jewish translator and scientific collaborator of the Castillian King Alfonso X, was the copyist of the manuscript. He knew only one manuscript of the work, the one he used, which increased his difficulties in understanding the *Kitāb al-asrār*. But his efforts led him to an almost complete reconstruction of the majority of the models described in the work, and he failed to understand only a few of them due to the incomplete state of the original manuscript or to difficulties impossible to overcome. Though this

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1. Donald R. Hill, "A Treatise on Machines by Ibn Muᶜādh Abū ᶜAbdallāh al-Jayyānī" *JHAS*, 1 (1977), 34-44.

2. A. I. Sabra, "A Note on Codex Biblioteca Medicea-Laurenziana Or. 152", *JHAS*, 2 (1977), 276-283.

3. Read at the University of Barcelona on the 2nd October 1975, now in press.

Thus his contributions to our field, while rivalling in significance those of many professionals, were made by an amateur. They were carried through in time snatched from the requirements of a demanding profession. All the more remarkable was it that, for example, any book review written by Hermelink was the fruit of deep and meticulous examination of everything the volume contained. This quality of his was the source of shamed admiration on the part of those of us who resent every minute spent in reviewing the books of others as being time lost to one's own work.

His own publications in the history of science were wide ranging, and included: recreational mathematics, number theory, magic squares, analemma methods, trigonometry, and Archimedean treatises which have survived in Arabic only. To these topics he brought all the virtues traditionally associated with German scholarship. His untimely death is a grievous loss to the many colleagues who counted him a personal friend, and a setback to the history of Arabic science.

Éloge

HEINRICH HERMELINK



11 DECEMBER, 1920 – 31 AUGUST, 1978

*By E. S. Kennedy**

As an infant, Heinrich Hermelink was a victim of poliomyelitis, and survived only as a severe cripple. Hence for him mere day-to-day living, let alone professional accomplishments, represented a continuing triumph over dire adversity. The physical disability made any public appearance inevitably conspicuous, and his wheelchair, his gracious wife, and he made up a poignant group familiar to historians of science attending scientific meetings.

In 1947 Hermelink graduated in physics from the Munich Technischehochschule. Following this he studied oriental languages and the history of mathematics at the University of Munich, taking the doctorate in 1952.

From a remark dropped by him in a conversation, one gathers that an academic career would have been most congenial (his father was a professor of church history at the University of Marburg), but continuing medical treatment demanded a more lucrative vocation. He entered a patent agency in 1952, and in 1957 commenced independent practice as a patent lawyer.

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King 4: D. A. King, "Astronomical Timekeeping (*ᶜIlm al-mīqāt*) in Medieval Islam" *Actes du XXIXᵉ Congrès International des Orientalistes* (Paris, 1973), II, 86-90.

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Mayer: L. A. Mayer, *Islamic Astrolabists and their Works* (Geneva, Albert Kundig, 1956).

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Neugebauer: O. Neugebauer, *The Exact Sciences in Antiquity*, 2nd. ed. (New York, Dover Publications, 1969).

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٦- باب في معرفة القبلة من الرسالة في العمل بالاسطرلاب لابـن النـطـاح

المصدر : مخطوطة لندن المكتبة البريطانية اضافية ٩٦٠٢ ، ق ١٨ ظ — ١٩ و

باب في معرفة القبلة اذا اردت معرفة القبلة بهاذا فخذ ارتفاع الشمس وضعها على مثل ارتفاعها واعرف سمتها واستخرج منه الجهات الاربع على ما بنيت في الباب قبل هذا فاذا عرفته فاترك الاسطرلاب على حاله ولا تحركه على ما هو عليه ثم در العضادة دون تحريك الاسطرلاب على ثلاثين درجة في ربع الارتفاع فما قابلت الشظية من الجهات فتلك هي القبلة بقرطبه وما قرب منها وهذا القبلة بقرطبة على خمس واربعين درجة ووجدت في معلقات عن ابى القاسم الصنيرى تضع[١] العضادة على ثلاث[٢] وعشرين درجة اذا كان عرض البلد لح ل هذا الذي ذكرته هو مذهب اهل صناعة التعديل واما الفقها فيرون الربع كله قبلة والمسجد الجامع بقرطبه على ستين واكثر مساجد قرطبة على مذهب البتانى رحمه الله وفيها ما هو على ثلاثين فان اردت معرفة القبلة بالليل فاستخرج الجهات الاربع على ما تقدم ثم در العضادة الى ربع اجزا الارتفاع على ما شئت من الاعداد التي ذكرت ان القبلة عليها بقرطبة فافهم .

التحقيق : ١ — في الاصل : يضع ٢ — في الاصل : ثلاثا .

القبلة ان شا الله [وانْ] اردت ان تعرف ذلك بوجه اخر نستوحى(؟) وقت مغربها في اليوم السادس [عش]ر او السابع عشر او الثامن عشر من يونيه فانهـــا في هذه الثلثة ايام يكون مغربها واحد فتقيم عودا قايما مستويا او تقف انت قياما مستويا فحيث انتهى ظلك او ظل العود فهو سمت القبلة بمشية الله تعلى وتوفيقه والعمل بوديالك [!] الى شى واحد وبالله التوفيق .

٣ـ قطعة من كلام موسى بن ميمون في عمل البلاطة

المصدر : كابانيلاس ص ٤٠٤ (ويلاحظ ان الاصل مكتوب بالحروف العبرية)

رخامة تبنى في الارض وترسم فيها خطوط مستقيمة مكتوب عليها اسماء الساعات وهي دائرة وفي مركز تلك الدائرة مسمار قائم على زوايا قائمة كلما سامت ظل ذلك المسمار لخط من تلك الخطوط علم كم ساعة مضات من النهار واسم هذه الآلة المشهور عند المنجمين البلاطة .

٤ـ قطعة من كتاب في الأنواء للحسن بن علي الأموي القرطبي

المصدر : مخطوطة اسكوريال ٩٤١ ، ق ٢٦ ظ

القول في رسم القبلة تعلم القبلـــة بالاندلس بان تضع القطب على كتفك الايسر ثم تستقبل الجنوب فما لقى بصرك فهو القبلة والقطب . . .

٥ـ قطعة من الرسالة في العمل بالاسطرلاب لابـــن الصفـــار

المصدر : **مياس** ، النص العربي ، ص ٦٥

. . . والثلاثون درجة من الربع الشرقي الجنوبي التي هي سمت للقبلة بقرطبة وما قرب منها . . .

لوحا او حجرا[4] مستوى السطح فتدير فيه دايرة دورها قدر الشبر وتقيم في مركزها قامة قدر نصف القطر على اعتدال ثم ترصد ظله في صدر النهار فاذا بلغ طرف الدايرة علم عليه بنقطة قبل أن تميل فاذا زالت الشمس ترصده ايضا فاذا بلغ الجانب الاخر من الدائرة علم عليه بنقطة ثم تقسم ما بين النقطتين على حرف الدائرة بنصفين وتعلم على وسط . . .[5] بنقطة ثم تخط خطا من ارض القامة الى نقطة الوسط فيكون هو خط [الزوال][6] فاذا وقع ظل القامة على الخط فهو نصف النهار بالاعتدال ثم تاخذ البلاطة حين يقع ظل القامة على الخط يثبتها في مكان مشرف على اعلى[7] حر معجون[7] اثباتا وتستقبل بوجوه الساعات جهة الجنوب حتى يقع ظل المرودين على الخطين اللذين هما اخر السادسة واول السابعة ثم تتقن لصوق البلاطة بالجبر[8] اتقانا حسنا ليلا تزيلها الرياح ثم نتعاهد النظر اليها اي وقت اردنا ان نعلم ما مضى من ساعات النهار وما بقى فانه لا يخفى عليك ذلك وهذا امر واضح فاعمل في ذلك كله من البلدان ان شا الله تعلى وهو المستعان وبه التوفيق وهذه صورته . . .

(٤ – ٤) – في الاصل : لوح او حجر ٥ – كلمة غير بينة في الاصل ٦ – كلمة غير بينة في الاصل
(٧ – ٧) – هكذا في الاصل ٨ – في الاصل : بالحبر .

٢ – بابان في معرفة ارتفاع الشمس نصف النهار بقرطبة وسمت القبلة بها من كتاب الأسرار في نتائج الأفكار

المصدر : مكتبة فلورنز لورينتريانا ١٥٢ ، ق ٤٨ ظ

ارتفاع الشمس عند حلولها بروس البروج بقرطبة ارتفاعها عند حلولها براس الجدي كو ارتفاعها عند حلولها براس الدلو لج . . . الحوت م . . . الحمل نال . . . الثور صج . . . الجبوزا عب . . . السرطان عه . . . الاسد ع . . . السنبلة صج . . . الميزان نا ل . . . الجوزا م . . . القوس لج الحمل نظيره الميزان الميزان نظيره الحمل الثور نظيره العقرب العقرب نظيره الثور ... ... السنبلة نظيرها الحوت الحوت نظيره السنبلة

باب في معرفة سمت القبلة [في مد]ينة قرطبة نستوحى طلوع الشمس يوم خمسة عشر او يوم ستة عشر [او يو]م سبعة عشر من دجنبر فانها في هذه الثلثة ايام يكون مطلعها واحد [في] اقصى مطلعه في الجنوب ومن حيث طلعت هو سمت

Thus there were several accepted *qibla* values in Cordova, and even astronomers such as Ibn al-Naṭṭāḥ preferred to invite his readers to choose their favorite one rather than take the trouble to compute one consistent with the mathematical and geographical knowledge of his time.

Appendix B

Arabic Texts

In this appendix I present the Arabic texts of (1) the chapter on the "sundial" by Ibn al-Ṣaffār taken from the *K. Natā'ij al-afkār* of al-Murādī; (2) the anonymous chapters on the meridian altitude and *qibla* at Cordova from the same work; (3) the passage on the same "sundial" by Maimonides; (4) an extract from the chapter on the *qibla* in the treatise on folk astronomy by al-Ḥasan b. ᶜAlī al-Umawī; (5) the passage on the *qibla* at Cordova in the treatise on the astrolabe by Ibn al-Ṣaffār; and (6) the chapter on the *qibla* in the treatise on the astrolabe by Ibn al-Naṭṭāḥ.

١– باب في عمل البلاطة لابن الصفار
كما ورد في كتاب الأسرار في نتائج الأفكار
لابن خلف المرادي

المصدر : مخطوطة مكتبة فلورنز لورينتزيانا ١٥٢ ، ق ٤٧ و — ٤٧ ظ

باب في عمل بلاطة تعرف[١] بها ساعات النهار على الحقيقة لابن الصفار تاخذ حجر كتان او رخامة وتنقش فيه على ما ياتى ذكره في شكله المصور ويكون الوسط الذي بين الساعات ثابتا خارجا عن وجه الساعات فيكون الوجه الواحد شرقيا يدل على ساعات النصف الاول من النهار والثانى غربيا يدل على ساعات اخر[٢] النهار ثم تقيم لكل واحد مرودا مثبتا في مجتمع الساعات على اعتدال واستوا يكون طول كل واحد قـدر عقدتين ثم[٣] تعمـد الى[٣] مكان مـا من الارض مستويـا وتجعـل فيـه؛

التحقيق . ١ – في الاصل : يعرف ٢ – في الاصل : اول (٣–٣) – غير واضح في الاصل

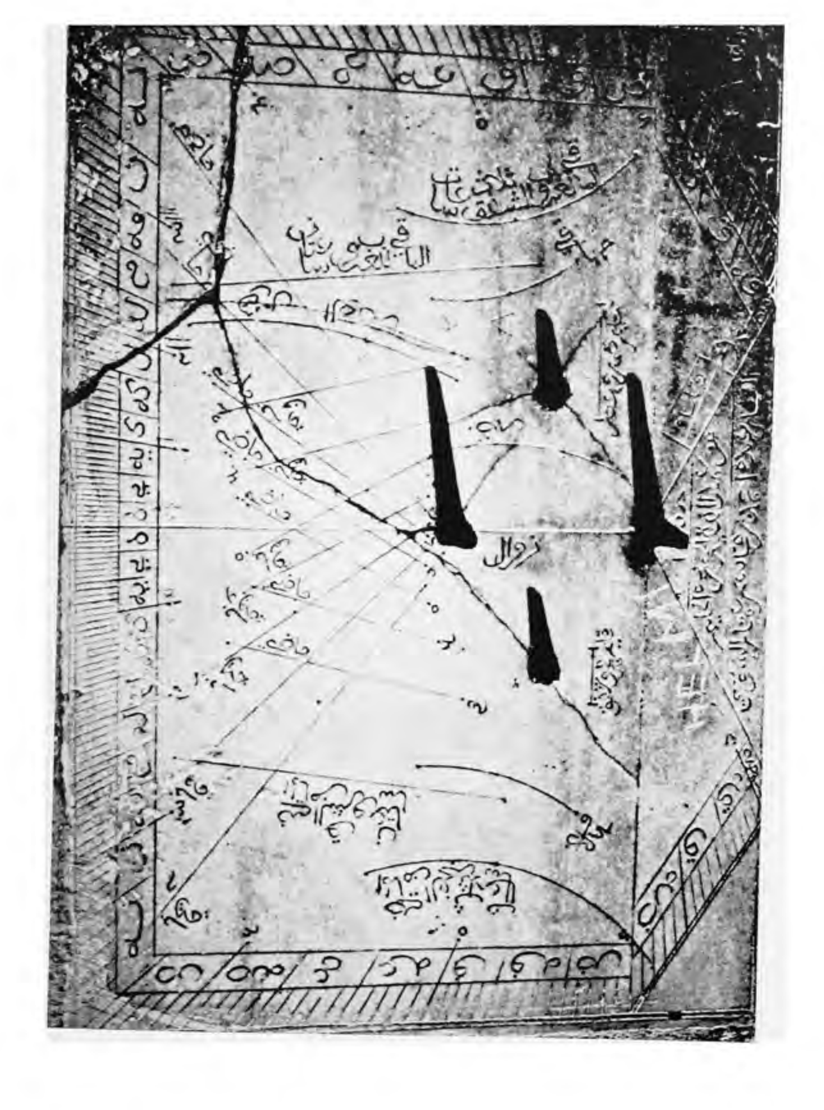


Plate 6: The sundial of the Mosque of Sidi Okba in Qayrawan.
(Courtesy René Rohr)

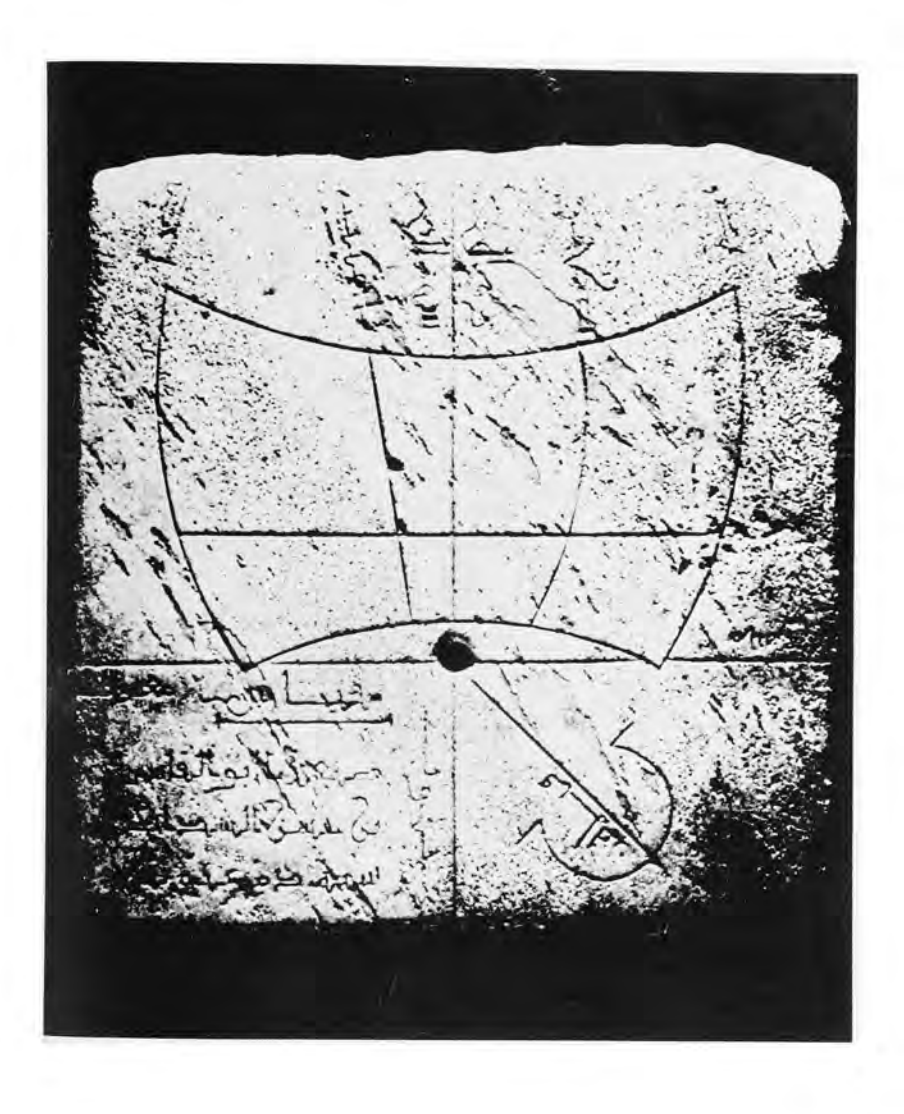


Plate 5: A fourteenth-century Tunisian sundial displaying the times of prayer.
(photo Alain Brieux, courtesy Francis Maddison)



Plate 4: The Granada sundial.

(photo Abumax)

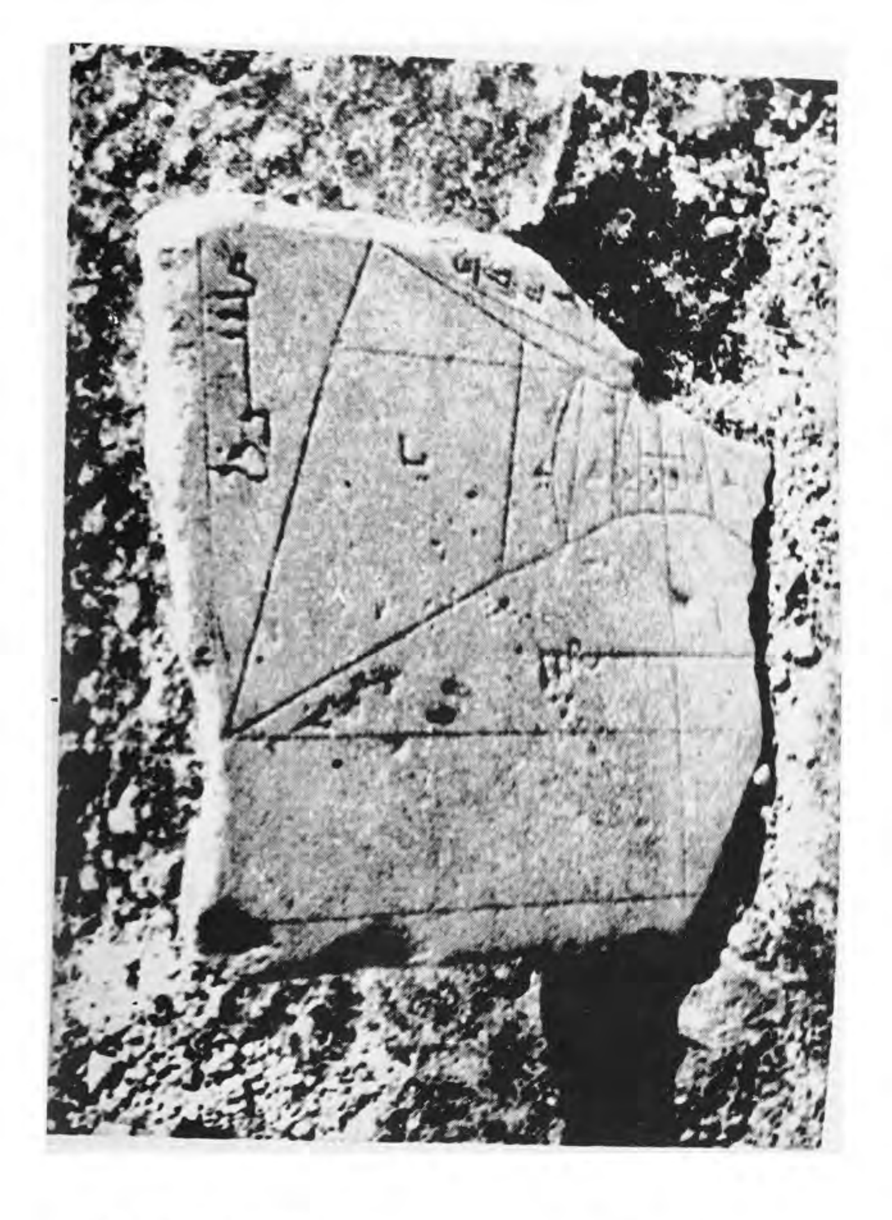


Plate 3: The Almeria sundial.

(photo Abumax)

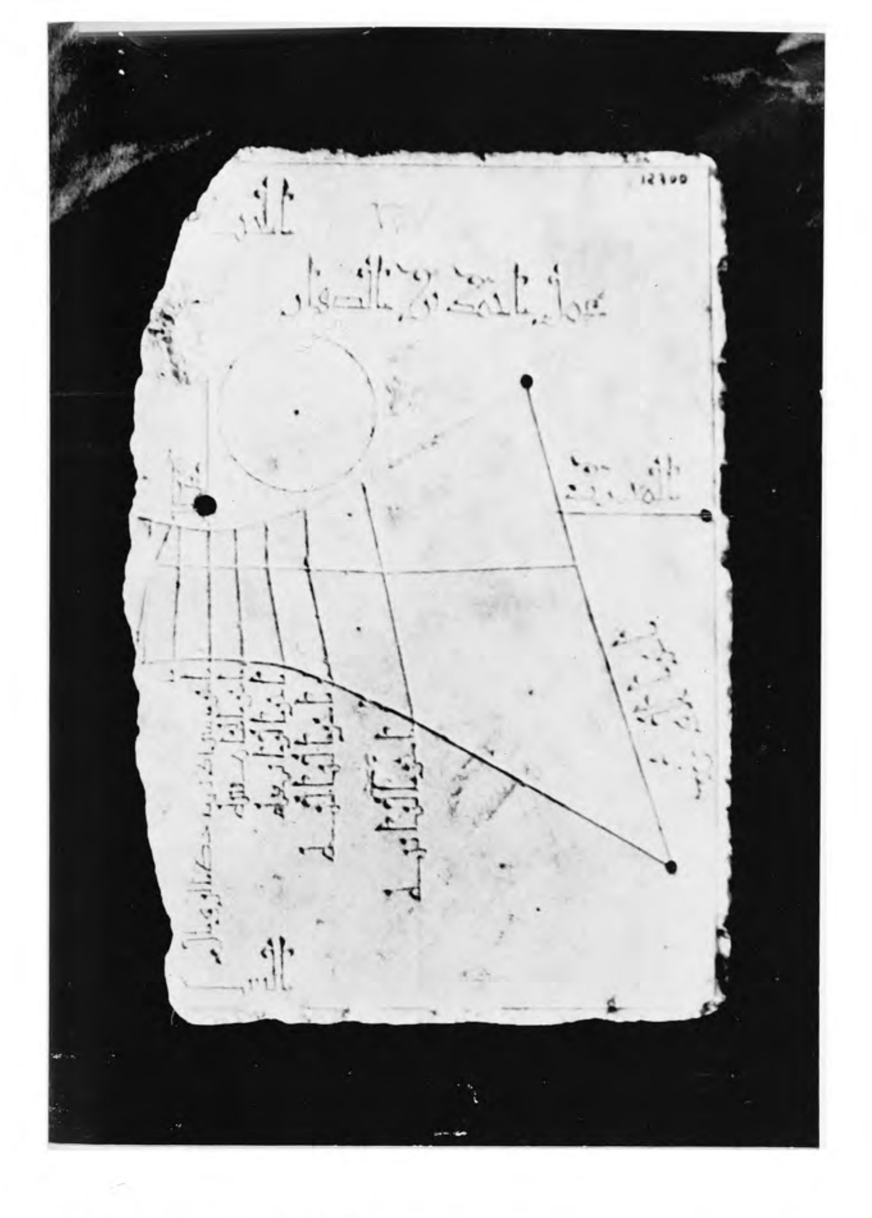


Plate 2: The sundial of Aḥmad b. al-Ṣaffār.

(Courtesy Museo Arqueologico Provincial de Cordoba)

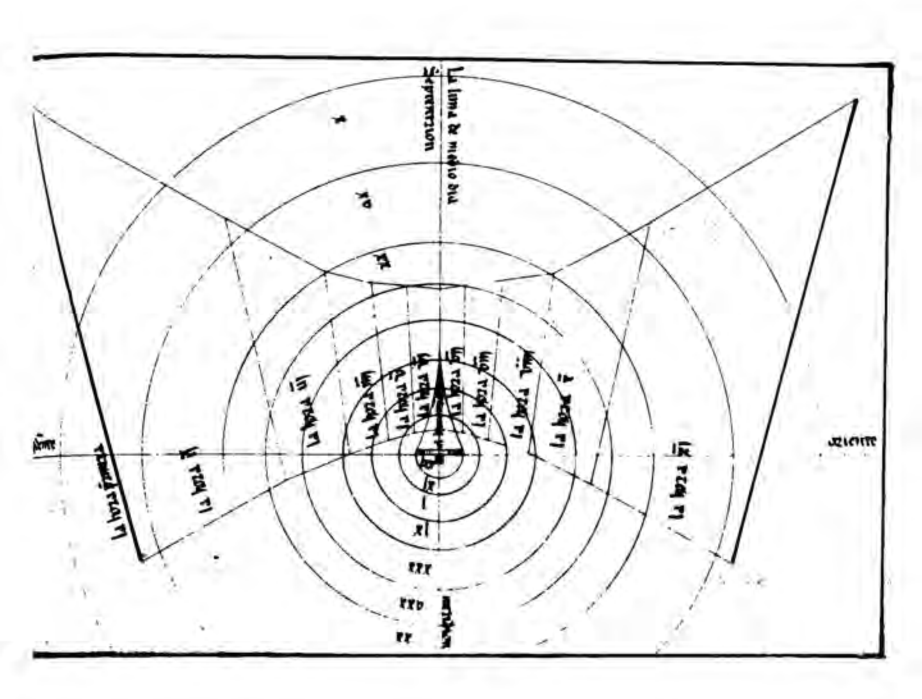


Plate 1: The horizontal sundial illustrated in the *Libros del Saber*.
(Courtesy Harvard University Library)

In his geographical tables[15] al-Battānī gives the following coordinates

	L	φ
Cordova	27;0°	38;38°(?)
Mecca	71; 0	21;40

With his geometrical construction we derive from these coordinates that the *qibla* at Cordova is about 23° S. of E., which is precisely the value attributed to "the astronomers" by Ibn al-Naṭṭāḥ.[16] I have no information on Abu'l-Qāsim al-Ṣnyry who is quoted by Ibn al-Naṭṭāḥ in the same context. The "correct" qibla for these coordinates, derived using the accurate mathematical formula, is 11° S. of E., and this is only 1° off the modern *qibla* for Cordova, which is 10° S. of E.

Ibn al-Naṭṭāḥ's remark that the *Jāmiᶜ* mosque in Cordova is at 60° (S. of E.) is incomprehensible to me because, as noted above, the Great Mosque of Cordova has its *qibla* wall due south. Ibn al-Naṭṭāḥ's other statement that most of the mosques in Cordova are laid out according to the opinion of al-Battānī, that is, at 23° S. of E., or at 30° S. of E., that is, the direction of the rising sun at the winter solstice, will be, or should be, of interest to historians of Andalusian architecture.

From the Granada sundial we know that south-east was also used as the *qibla* in Andalusia. The direction 45° S. of E. would have been handy for the *qibla* in Andalusia since, as Ibn al-Naṭṭāḥ says, the legal scholars thought that the whole (south-eastern) quadrant was the *qibla*. The *qibla* indicator on the Tunisian sundial also points due south-east, and although this *qibla* is grossly inaccurate for Tunis, it is a happy compromise between due east and due south, both of which directions are attested for *qiblas* of medieval Maghribi mosques.[17]

15. Nallino, III, pp. 234-242. The reading of the minutes in the latitude of Cordova appears to be in error.

16. Other medieval coordinates yield similar but not identical results. For example, al-Marrākushī, an astronomer of Moroccan origin who worked in Cairo *ca.* 1280, recorded the following geographical coordinates (*Sédillot-père*, I, pp. 202-204 and 315-317):

	L	φ
Cordova	27;0°	38;30°
Mecca	77;0	21;0

Using al-Battānī's method I derive a qibla of 21° S. of E. Again, in the *Toledan Tables*, a hodge-podge of tables culled mainly from the *Zījes* of al-Battānī and al-Khwārizmī, and compiled in Toledo in the thirteenth century, we find the following coordinates (*Toomer*, pp. 134-139, nos. 3 and 16):

	L	φ
Cordova	9;20°	38;30°
Mecca	67;0	21;0

These coordinates are derived from those of Ptolemy, and were used by al-Khwārizmī. I compute that they yield a *qibla* of 20° S. of E. using al-Battānī's method.

17. *Cf. King* 2, p. 190-191.

The treatise on the use of the astrolabe by Ibn al-Ṣaffār,[4] published by J. Millás Vallicrosa, contains a remark (Appendix B, extract 5) that the *qibla* at Cordova is 30° south of east.[5] The treatise on mechanical devices entitled *Kitāb al-Asrār fī natā'ij al-afkār* by Ibn Khalaf al-Murādī[6] concludes with a chapter on the *qibla* at Cordova (Appendix B, extract 2), in which the author states what is equivalent to an assertion that the *qibla* there is in the direction of the rising sun at the winter solstice. The two directions given in these two sources are in fact the same,[7] and al-Murādī's definition explains the value of Ibn al-Ṣaffār.

The local direction of the rising sun at the winter solstice was also taken as the *qibla* in early Muslim Egypt.[8] The justification for such *qibla* determinations appears to result from an early Islamic tradition of using *al-Jady*, the Pole Star, to find the *qibla*.[9] As we have seen in the treatise of al-Ḥasan b. ʿAlī al-Umawī, what was intended was that if one stood with one's back to the Pole Star one would be facing the *qibla*. Since one would be in fact facing due south, this injunction is valid only for points due north of Mecca. However, when Muslim domination extended eastwards and westwards, another interpretation was given to the injunction, and *al-Jady* was taken to refer to the sign of Capricorn. At the winter solstice the sun is at the first point of Capricorn; its rising point was used for the *qibla* in Egypt and Andalusia.

A fourth discussion of the qibla at Cordova occurs in a treatise on the use of the astrolabe by an individual named Ibn al-Naṭṭāḥ,[10] extant in the unique copy MS London B.L. 9602,1 (fols. 1v-24v, copied *ca.* 600H). Ibn al-Naṭṭāḥ's treatise was apparently well esteemed in its genre: a note in MS Cairo Dār al-Kutub *hay'a* 10, fol. 39v, copied after 1163H by a Maghribī astronomer, states that the best treatises on the astrolabe are these of Ibn al-Naṭṭāḥ and of Ibn al-Samḥ.[11] Ibn al-Naṭṭāḥ's remarks are found on fols.

4. On Ibn al-Ṣaffār see note 9 above.

5. *Millás*, p. 65 of the Arabic text.

6. See note 22 above.

7. For $\varphi = 38^\circ$ (the latitude of Cordova is actually 37;53°) and $\varepsilon = 23;35^\circ$, the azimuth of the rising sun at midwinter is 30;31° S. of E. For $\varphi = 38;30^\circ$, a value popular with Andalusian astronomers, the azimuth would be about 30;45° S. of E.

8. See the article *Kibla* in EI_2.

9. See, for example, the treatise on folk astronomy by Ibn Qutayba (fl. 850), p. 122.

10. Ibn al-Naṭṭāḥ and the London manuscript of his treatise on the astrolabe are listed in *Suter*, No. 499. He is not mentioned in *Millás* (!), and I have no other information on him.

11. On Ibn al-Samḥ see *Sezgin*, V, p. 356 (the treatise on arithmetic contained in manuscripts in the Escorial and in Berlin is not by Ibn al-Samḥ) and VI, to appear. His treatise on the astrolabe is extant in the unique copy MS London B. L. 9602,2 (fols. 25v-55v, copied ca. 600H, defective at end). This treatise of course contains a chapter on the determination of the *qibla*, but no values are given for anywhere in Andalusia.

comprises four main sets of markings: (1) graduations around the edge of the sundial from which the hour-angle can be read using the shadow of a thread attached at the centre of the graduations and oriented in the direction of the celestial pole; (2) markings displaying the seasonal hours since sunrise and before sunset; (3) markings for the *ẓuhr*[28] and *ᶜaṣr*, the latter being duplicated; and (4) markings displaying time relative to daybreak and nightfall. The first part of the sundial is called *al-musātara* in late medieval Arabic,[29] and the development of this kind of hour-angle dial in medieval Islam remains to be studied. On the second part of the sundial there are no shadow-traces for the equinoxes and solstices, and this feature, not attested on any of the Egyptian, Syrian, or Turkish sundials currently known to me, may be the result of a Maghribī innovation in gnomonics: since it is so difficult to draw acceptable hyperbolae, leave out the shadow-traces altogether.

Appendix A

Some Medieval Values of the Qibla at Cordova

Very few astronomical works compiled by Andalusian astronomers have survived in the manuscript sources, so that there is not much hope of recovering written material on the *qibla* in Andalusia.[1] Treatises which deal with the determination of the *qibla* without giving specific examples do not concern us here, and I have found references to the specific values of the *qibla* in Andalusia in only four Andalusian treatises. Details follow.

The treatise on folk astronomy written by the late twelfth century Cordova scholar Abū ᶜAlī al-Ḥasan b. ᶜAlī b. Khalaf al-Umawī,[2] which is extant in the unique MS Escorial ar. 941 (38 fols., *ca.* 800H), contains a statement (fol. 26v, see Appendix B, extract 4) that to find the *qibla* in Andalusia one should stand with the celestial pole behind one's left shoulder and face south. It was probably on this kind of authority that the Great Mosque in Cordova, which dates from *ca.* 785, was built with its *qibla* wall facing due south.[3]

28. In *Janin*, p. 210, the shadow increase at the beginning of the *ẓuhr* is given incorrectly as $\frac{1}{3}n$ rather than $\frac{1}{4}n$.

29. *Cf. Janin-King*, pp. 199-200 and 214.

1. For a brief introduction to the determination of the *qibla* in medieval Islam see the article *Kibla* in EI_2 by A. J. Wensinck (religious aspects) and myself (mathematical aspects).

2. On al-Umawī see *Suter*, no. 323.

3. *Creswell* 1, II, pp. 145-146 (repeated in *Creswell* 2, p. 216) stated: "(The Mosque) is set, as nearly as can be measured, exactly north and south, although the direction of Mekka from Cordova is 10°14' S. of E". A remark such as this reflects the misunderstanding of orientations of medieval Islamic buildings common amongst historians of Islamic architecture. Such orientations are usually to be explained in terms of medieval *qibla* values, if they can be explained at all.

888H. This treatise, arranged in 44 *faṣls* with numerous diagrams but without tables, treats of the construction of horizontal sundials with markings for the hours and the prayer-times. This work merits detailed investigation.

(3) An anonymous treatise on the construction of a horizontal sundial displaying the seasonal hours for the latitude of Fez, 33;40°, is contained in MS Cairo Taymūr *riyāḍa* 141,6, pp. 146-156, copied *ca.* 1100H. The treatise contains tables displaying the shadow lengths and azimuths at each hour for both solstices, with values to two sexagesimal digits.

(4) An anonymous Maghribī treatise on the construction of a sundial displaying the times of the *ẓuhr*, and the beginning and end of the *ᶜaṣr* (corresponding to shadow increases of $\frac{1}{2}$ n, n, and 2 n) is contained in MS Cairo Ḥalīm *miqāt* 19,3+4, fols. 45v-58r, copied 1144H. The author states triplets of both azimuth values and shadow lengths for each of the three times at the solstices and equinoxes. Values are given to the nearest degree or unit, and are stated to be for the latitude of Fez (value not stated). The azimuth values given for the beginning and the end of the *ᶜaṣr* are the same.

(5) An isolated table of coordinates for constructing a horizontal sundial displaying the seasonal hours for the latitude of Marrakesh, 31;30°, is contained in MS Cairo Taymūr *riyāḍa* 131,2, p. 1, copied *ca.* 1200H in Maghribī script.

(6) A treatise entitled *Rawḍat al-nāẓir fī kayfīyat waḍᶜ khuṭūṭ faḍl al-dā'ir* by Muḥammad al-Idrīsī is preserved in MS Cairo Dār al-Kutub *mīqāt* 1169,2, fols. 11v-25v, copied 1223H. This treatise, arranged in 4 *bābs*, deals with the construction of a horizontal sundial with markings for the seasonal and equinoctial hours and the prayer-times, and it contains several tables computed for the latitude of Tunis, 36;51°. The author quotes other Maghribi writers named Ibn al-Najjār and Abū ᶜAbd Allāh Muḥammad Kwynkh (?), author of a treatise on sundial theory entitled *Iḥyā' al-mawāt fi'l-basā'iṭ wa-l-munḥarifāt*, as well as the two well-known Egyptian astronomers Ibn al-Majdī and Sibṭ al-Māridīnī.[26] The kind of sundial discussed in this treatise apparently became known in the Maghrib from the Muslim East, and its introduction there seems to have occurred rather late, that is, *ca.* 1600. One kind of late Maghribī sundial is illustrated in Plate 6, which shows the sundial of the Mosque of Sidi Okba in Qayrawan in Tunisia, constructed in 1258H (= 1842 A.D.) and recently discussed by L. Janin.[27] This kind of sundial is late, and not related to the Andalusian tradition. As Janin has shown, it

26. *Suter*, nos. 432 and 445.
27. See *Janin*, especially pp. 208-211.

preserved in the unique MS Florence Medicea-Laurenziana Or. 152, fols. 1v-48v, copied 664H (= 1266) in Maghribi script, and the passage occurs on fols. 47r-47v (see Appendix B, extract 1). The same type of sundial is described by another scholar of Cordova, namely, Maimonides.[23] In his commentary on the *Mishna* Maimonides gave a much more succinct account of the sundial than Ibn al-Ṣaffār. The text (see Appendix B, extract 3) translates as follows:

> A piece of marble *(rukhāma)* is fixed on the ground and straight lines are drawn (as radii) with the names of the hours written on them (to form) a circle. In the centre of that circle there is a nail standing perpendicular (to the plane of the circle), and whenever the shadow of that nail is in the same direction as one of those lines, it is known how many hours of daylight have passed. The name of this instrument, which is used by the astronomers, is the *ballāṭa*.

Ibn al-Ṣaffār's text confirms that what is intended is to form a semicircle with the diameter oriented east-west and the circular part towards the north. The twelve hour-lines are the radii at 15° intervals from west to east. There is no suggestion that the dial be oriented in the plane of the celestial equator, when it could indeed be used to display equinoctial hours before or after midday. Rather, the dial is horizontal, and it is assumed that the sun rises due east and sets due west, and that its change in azimuth is proportional to the passage of the seasonal hours.

A far more interesting instrument for timekeeping is described and illustrated by al-Murādī as the last of the thirty-one devices presented in his book (fols. 45r-46v). This is a horizontal dial of the kind known in other medieval Arabic souces as *shāmila* or *musātara*, although in al-Murādī's text it is simply labelled "a kind of *ballāṭa*". This dial was as far as we know invented by al-Khujandī in the tenth century, although the one described by al-Murādī may be an Andalusian invention. In any case the Islamic tradition of horizontal dials in general awaits study.[24]

(2) A treatise by the early fourteenth century Tunisian (?) astronomer Ibn al-Raqqām[25] is extant in MS Escorial ar. 918,11, fols. 68v-82v, copied

23. This passage is quoted without comment in *Cabanelas*, pp. 404-405. The original text was in Judaeo-Arabic written in Hebrew characters.

24. See *Janin-King*, p. 199, and the references there cited. Al-Khujandī's treatise is currently being studied by Dr. R. Lorch.

25. On Ibn al-Raqqām (was he Tunisian or Andalusian?) see *Suter*, nos. 388 and 417, *Renaud*, no. 388, and *King* 2, pp. 191 and 192. All of his works merit detailed investigation.

and hence to date the sundial![21] For the Tunisian sundial I computed $\varphi \approx 37^{\circ}$, which corresponds quite well to Tunis. For the Cordova sundial I have derived $\varphi \approx 39\frac{1}{2}^{\circ}$, which serves Cordova. But I doubt that one should attempt to compute the latitude underlying sundials as crude as the Almeria or Granada sundials.

Conclusions

Rather than assert on the basis of our investigations of the only three sundials known from Islamic Spain that the Andalusian astronomers were not competent in gnomonics, we can only conclude that these three surviving specimens are not particularly impressive when viewed in the light of the sundial theory of Abbasid Baghdad. Are there any other sundials from Islamic Spain? A single dial could greatly add to our knowledge of Andalusian sundial construction.

Another source for our knowledge of Andalusian gnomonics would be treatises on the construction and use of sundials, but there are very few known treatises on this subject of Andalusian or even Maghribī provenance. Besides the treatise in the *Libros del Saber*, I know of only the following:

(1) A short passage attributed to Ibn al-Ṣaffār in a twelfth-century Andalusian treatise on mechanical devices by Ibn Khalaf al-Murādī[22] describes at length a "sundial" for measuring the hours "correctly". The treatise is

21. In *de Orús* the Almeria sundial is dated to the end of the tenth century or the beginning of the eleventh by the following method. Measuring the eccentricity, e, of the "hyperbola" for the winter solstice as 2.00, and taking $\varphi = 36°50'$ for the latitude of Almeria, the obliquity of the ecliptic, ε, is determined using the relation $\cos \varphi = e \sin \varepsilon$, and found to be 23°34'. Newcomb's formula for the secular variation of ε is then used to derive an approximate date for the sundial.

22. On this treatise see *King* 3, p. 289, *Hill*, and *Sabra*. The chapter by Ibn al-Ṣaffār (*Sabra*, p. 280) is followed by a chapter on the determination of the meridian, correctly attributed to al-Battānī (fols. 47v-48r; *Sabra*, p. 280, states that this is anonymous), and by two anonymous chapters (both on fol. 48v) dealing with the meridian altitudes of the sun in the signs at Cordova and on the qibla at Cordova. These two chapters may be due to Ibn al-Ṣaffār (as suggested in *Sabra*, pp. 280-281). The solar meridian altitudes are based on latitude 38;30° and obliquity *ca.* 23;30°: values are given to the nearest half degree for each zodiacal sign. On the value stated for the qibla at Cordova see Appendix A.

As Sabra has pointed out (*Sabra*, p. 278), the author of this treatise is named as . . . (?) Ibn Khalaf al-Murādī rather than the eleventh century scholar Ibn Muʿādh as was assumed in *Hill*. However, Sabra read the last and only visible letter of the name preceding the word *ibn* as a *nūn* (= *n*), when it is actually a *dāl* (=*d*). From Toledo in the mid-eleventh century there were two scientists named ʿAlī b. Khalaf and ʿAbd Allāh b. Khalaf (*Blachère*, pp. 138-139) who cannot be the authors. Aḥmad b. Khalaf and Muḥammad b. Khalaf, both celebrated astrolabists of ninth-century Iraq (*Ibn al-Nadīm*, pp. 284-285), are also not candidates. Neither, most probably, are Muḥammad b. Khalaf al-Qurṭubī (d. 557/1162), author of a legal work listed in *Brockelmann*, I, p. 185, or al-Ḥasan b. ʿAlī b. Khalaf al-Umawī al-Qurṭubī (d. 602/1205-06), author of a work on folk astronomy listed in *Suter* no. 323.

XY measures the length of the gnomon, because it is about the same length as OW.

We now observe that the hour-lines divide equally the two east-west lines: this reveals the method by which they were constructed. But how did the maker construct the first and eleventh hour-lines, AB and CD? Notice that AOD and BOC are more or less straight lines and that they are inclined at approximately 45° to the meridian. Notice also that OA and OC are roughly twice OB and OD. The reason why the maker might have used the approximation $OA \approx 2\ OB$ is clear from Ibn al-Ṣaffār's sundial. Notice also that OA and OC are roughly twice the length x, but OA and OC should be about four times the length of the gnomon, so that x cannot represent the length of the gnomon. The directions that the maker chose for AOD and BOC are nice and symmetrical but not so reasonable.

Notice that the winter-solstice shadow at the *ᶜaṣr*, is in excess of the midday shadow OW by the length x. From this one might conclude that the length x was a measure of the length of the gnomon, but the relationship is fortuitous. Both the *ẓuhr* and *ᶜaṣr* curves have been drawn as arcs subtended by the seventh and ninth hour lines. If we superimpose the Cordova and Granada sundials we see that the error in the time of the *ᶜaṣr* displayed by the Granada sundial is about one hour.

In a recent publication I have discussed in some detail the Tunisian sundial mentioned above,[20] but at the time of writing that paper I was not aware of the existence of the Granada sundial. The Tunisian sundial displays four times of day with religious significance, including the *ẓuhr* and the *ᶜaṣr* prayers and a morning prayer at the same time before midday as the *ᶜaṣr* after midday. Each of the curves for these three times is drawn as an arc of a circle, as are the shadow-traces for the solstices. I have already proposed a method of constructing such a sundial, but I think that I may have placed too much emphasis on the possible use of calculation, or even tables of the kind well attested in the astronomical traditions of Egypt, Syria, and the Yemen, rather than geometrical construction, in the marking of this Tunisian sundial. I also now question the validity of trying to derive the local latitude for which such an approximate sundial was drawn, although it is certainly more valid than attempting to derive the value of the obliquity underlying the markings

20. *King* 2. In this paper the dimensions of the sundial are given (p. 187) as 24 × 34 cm.: read 24 × 24 cm. Also, the time of the *ta'hīb* shown on the sundial (see p. 190) does indeed relate to the Friday prayers: in the anonymous Moroccan treatise of sundials preserved in MS Cairo Ḥalīm *mīqāt* 19 the author mentions the first and second *ta'ahhub* on Friday (fol. 47v). Unfortunately he gives no further information.

drawn using a geometric construction of the kind known as analemma,[13] or by using tables of coordinates of the intersections of the hour lines with the three shadow traces taken from tables prepared in advance. The only known tables for constructing sundials which predate the time of Ibn al-Ṣaffār are those of al-Khwārizmī, compiled in early ninth century Baghdad,[14] and displaying the coordinates of the intersections of the hour-lines with the two solsticial traces. Al-Khwārizmī gave values of the shadow length, measured from the foot of the gnomon, and the azimuth, measured from the east-west line, for each hour at both solstices and for a series of terrestrial latitudes, including 38° and 40°. In view of the fact that some of the hour-lines on Ibn al-Ṣaffār's sundial consist of two segments drawn between each of the shadow-traces for the solstices and that for the equinoxes, it follows that if he used tables, then they must have displayed coordinates for the equinoxes, although these are superfluous since the hour-lines are taken as straight lines. To construct the lines using an analemma one likewise needs only two sets of points. But Ibn al-Ṣaffār used three. Furthermore, the fact that the segments between the shadow traces at the equinoxes and the summer solstice for the third, fourth, fifth, seventh, and eighth hours are more or less parallel to the meridian indicates the seriousness of his error. The curve for the *ẓuhr* was probably constructed by joining the three points on the shadow traces which are such that their distance from the gnomon is the meridian shadow increased by the standard one quarter of the length of the gnomon. However, one might think from looking at Ibn al-Ṣaffār's sundial that the *ẓuhr* was at about 1⅓ seasonal hours after midday at the summer solstice and at about 2⅓ seasonal hours after midday at the winter solstice. In fact, the curve for the *ẓuhr* should not cross the eighth hour line.[15]

The remains of Ibn al-Ṣaffār's sundial do him little credit. One might have expected something better from one of the leading astronomers of Andalusia, when that province of the Islamic world was close to its cultural zenith. Nevertheless Ibn al-Ṣaffār's sundial is a better specimen than the two that we shall investigate next.

(b) *The Almería Sundial*

The second sundial is preserved in the Museo Arqueológico de Almeria, and is displayed in Plate 3. It has been described by Juan J. de Orús (1956) and Dario Cabanelas (1958).[16] A substantial part of the western half of the sundial is missing, and the maximum dimensions of the remaining portion of the marble slab are 28 × 29 cm.

13. On the analemma see *Neugebauer*, pp. 214-218 and the references there cited.
14. See note 5 above.
15. *Cf. King* 2, p. 191.
16. *Cf. de Orus*, and *Cabanelas*, pp. 392-394. See also note 18 below.

meridian.[11] This hole has been violated by the gnomon to such an extent that its centre is no longer on the meridian. A segment perpendicular to the right edge of the sundial when extended passes through this hole and represents the east-west direction. The three lines which are drawn across the meridian are: closest to the hole, the hyperbola representing the shadow trace at the summer solstice (when shadows are shortest), next, a straight line representing the shadow trace at the equinoxes, and, furthest from the hole, the shadow trace at the winter solstice (when shadows are longest). The lines drawn across these three lines indicate the seasonal hours of day, starting at the first on the right, then the second, third, fourth, and fifth, then the sixth, which is precisely midday because we are dealing with seasonal hours that are one-twelfth divisions of daylight, and then the seventh and eighth. The hour-lines are marked *ākhir al-ūlā*, "end of the first (hour)", *ākhir al-thāniya*, "end of the second (hour)", *etc.* The curve close to the left hand edge of the sundial indicates the time for the *ẓuhr* prayer. We may presume that the sundial originally bore a curve for the beginning of the *ᶜaṣr* prayer as well.

We now investigate the markings more closely, firstly to establish the underlying latitude, and secondly to ascertain the accuracy of the markings. All of the measurements are based on the photograph illustrated in Plate 2. The length of the gnomon is $n = 9\frac{1}{2}$ mm., and the midday shadow at the winter solstice OW is $18\frac{1}{2}$ mm. Thus

$$9\tfrac{1}{2} \cot(\bar{\varphi} - \varepsilon) = 18\tfrac{1}{2}$$

so that

$$\cot(\bar{\varphi} - \varepsilon) = 1;57, \quad \bar{\varphi} - \varepsilon \approx 27^\circ \quad \text{and} \quad \varphi + \varepsilon \approx 63^\circ$$

But $\varepsilon \approx 23;30^\circ$, so that

$$\varphi \approx 39;30^\circ,$$

which is close to the standard medieval Islamic value for the latitude of Cordova 38;30°.[12] The accurate value for Cordova is 37;53°.

A glance at the sundial reveals several defects. Firstly, the equinoctial shadow trace is not a straight line, as it should be. Secondly, the lines for the third and fourth and eighth hours are not straight, as, in a sundial of this size, they should be. These defects are so obvious to anyone with the most modest knowledge of gnomonics, that we may well wonder why Ibn al-Ṣaffār put his name to the sundial. We cannot be sure whether the markings were

11. *Cf. Cabanelas*, p. 396, where it is suggested that the circle serves no purpose other than decoration.

12. This is easily confirmed by consultation of the computer print-out of medieval Islamic geographical coordinates described in *Kennedy-Haddad*.

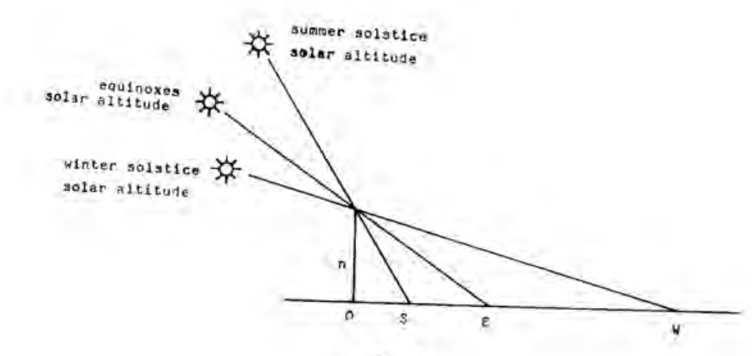


Fig. 1

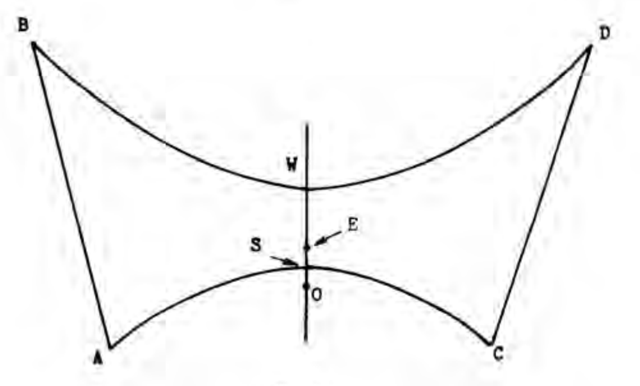


Fig. 2

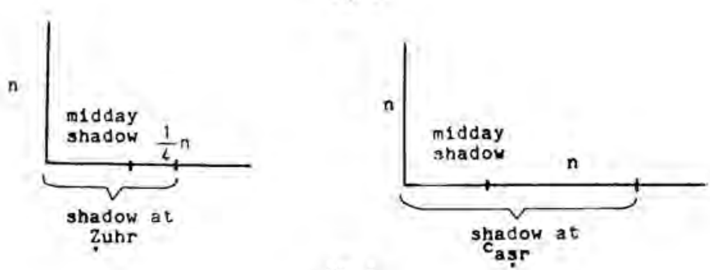


Fig. 3

in Andalusian practice are that the gnomon shadow shall have increased beyond its midday minimum by $\frac{1}{4}$ *n* and *n*, respectively (see Fig. 3).[7]

(a) *The Cordova Sundial*

In the Museo Arqueológico Provincial in Cordova there is a fragment of a horizontal sundial, illustrated in Plate 2, which was found in the Camino Viejo de Almodovar in Cordova. It has been published by Samuel de los Santos Jener (1955) and Dario Cabanelas (1958).[8] The instrument bears the name of Aḥmad ibn al-Ṣaffār, an astronomer of some renown who worked in Cordova about the year 1000 A.D.,[9] and is thus the oldest surviving Islamic sundial, although it has not been previously identified as such.[10]

The remains of the Cordova sundial consist of a little more than half of the original instrument. The dimensions of the original sundial were 48 cm. (approx.) × 34.5 cm. × 4.5 cm. The inscriptions are in elegant floriated Kufic, and the maker's name appears in the upper right corner. The cardinal directions are marked on the sundial, which is broken just to the left of the meridian, or north-south line. The hole on this line once carried a vertical gnomon, the length of which is indicated by the radius of the circle to the right of the

7. On the times of prayer in Islam see *Wiedemann-Frank*, A. J. Wensinck's article *Mīḳāt* in EI_1, and *King* 4. For an explanation of the definitions in terms of the increase of the shadow see *King* 2, Appendix B. A more detailed study on the origin of the definitions of the times of prayer in Islam is in preparation.

8. *Cf. de los Santos* and *Cabanelas*, pp. 394-396. See also notes 10 and 11 below.

9. On Ibn al-Ṣaffār see *Blachère*, p. 131, and the article by B. R. Goldstein in EI_2, III, p. 924, and the references there cited, to which add now *Sezgin*, V, pp. 356-357, and VI, to appear. Aḥmad ibn al-Ṣaffār had a brother Muḥammad who was a maker of astrolabes (*cf. Mayer*, p. 75, for details of an instrument made by him in the year 1029).

Ibn al-Ṣaffār was a student of the Andalusian astronomer and mathematician Maslama al-Majrīṭī, author of a recension for Andalusia of the *zīj* (astronomical handbook consisting of text and tables) of the ninth century Baghdad astronomer al-Khwārizmī (on whom see G. Toomer's article in *DSB*). Ibn al-Ṣaffār also compiled a *zīj* based on the methods of the Indian *Zīj al-Sindhind* (*Kennedy*, no. 17). Only the introduction to Ibn al-Ṣaffār's *zīj* survives, namely, in an Arabic manuscript written in Hebrew characters preserved in the Bibliothèque Nationale in Paris (the tables in this manuscript are not related to Ibn al-Ṣaffār). His only other known work is a treatise on the use of the astrolabe, which was popular amongst later Muslim astronomers and is extant in several copies (the Arabic text of this treatise was published by J. Millás Vallicrosa in 1955), and was also translated into Latin and Hebrew. In his later years Ibn al-Ṣaffār moved from Cordova to Denia, where he died in the year 1035.

10. In *de los Santos* the name is read Aḥmad b. al-Ṭulb, and in *Cabanelas*, p. 396 as Aḥmad b. al-Ṣawwār. I agree that the reading *ṣawwār* is easier to justify than *ṣaffār* (the dot over the middle radical is a scratch), but firstly "ṣawwār" is not attested as a name meaning "diseñador, delineante, pintor", and secondly Aḥmad b. al-Ṣaffār was a well-known astronomer of Cordova.

The three sundials are preserved now in three different museums in Spain, and I shall henceforth designate each of the sundials by its present location, namely, Cordova, Almeria, and Granada. All of the sundials are of the horizontal kind designed for a specific latitude and displaying the seasonal hours of day. Such sundials were used already in antiquity,[4] and are described in the earliest Arabic treatises on sundials.[5] They are also described in the thirteenth century Andalusian *Libros del Saber* (see Plate 1).[6]

Two of the Andalusian sundials are broken, but each of them displays all or parts of three main sets of markings. These are (a) the north-south line and shadow-traces for the solstices and equinoxes; (b) the hour lines for each seasonal hour of daylight from the end of the first hour to the end of the eleventh hour; and (c) the curves for the midday *(ẓuhr)* and afternoon *(ᶜaṣr)* prayers. Each sundial was originally fitted with a gnomon erected vertically in a hole in the sundial; in all cases, these gnomons are now missing.

I shall use the following notation freely. The points at which the shadow-traces for the summer solstice, equinoxes, and winter solstice, intersect the north-south line (see Fig. 1) are labelled S, E, and W. The base of the gnomon is O, and its length is n. The most commonly used length of the gnomon in Islamic sundial theory was 12 units. Clearly, for a locality with latitude φ (see Fig. 2):

$OS = n \cot(\bar{\varphi} + \varepsilon)$; $OE = n \cot \bar{\varphi}$; and $OW = n \cot(\bar{\varphi} - \varepsilon)$, where ε is the obliquity of the ecliptic and $\bar{\varphi} = 90^\circ - \varphi$. For Andalusia $\varphi \approx 38^\circ$ and approximately $OW{:}OS = 7\frac{1}{2}{:}1$. Also, E is roughly at the point of trisection of SW closer to S, so that approximately $SE{:}EW = 1{:}2$. The lines for the first and eleventh hours between the summer shadow-trace and the winter shadow-trace are labelled AB and CD.

The standard definitions of the times for the *ẓuhr* and *ᶜaṣr* prayers

4. See *Gibbs*, pp. 39-42 and 323-338.

5. See *Sezgin*, VI, *passim*. An important aspect of these treatises is the tables of coordinates for marking sundials which some of them contain. I am currently preparing an edition of al-Khwārizmī's sundial tables, and a survey of all later Islamic sundial tables. For a brief introduction see *King* 1, pp. 51-53 and 56.

6. *Libros del Saber*, IV, pp. 1-23. No author is associated with this treatise, which was written especially for Alfonso X because no book on the subject could be found which was "complete in itself" (*Procter*, p. 18). It is in two parts arranged in 14 and 4 chapters, and deals with the construction and use of a horizontal sundial marked for the seasonal hours (see also *Cabanelas*, pp. 400-403). The treatise contains tables of the solar declination, and the sine and cotangent functions, but no tables or geometrical procedures for constructing the kind of sundial described in the text. The latter is distinguished from the three Andalusian sundials described in this paper by the inclusion of circles drawn about the gnomon corresponding to the shadows of each 5° of solar altitude, and by the fact that there are no curves for the prayer-times, since these would no longer be of concern to a Christian reader.

Three Sundials from Islamic Andalusia

DAVID A. KING*

In memory of my friend Louis Janin.

In this paper I propose to discuss three sundials from medieval Andalusia.[1] Each of these sundials has been published previously, in the sense that photographs and a list of the Arabic inscriptions have been published,[2] but in the present study I shall attempt to investigate the markings on the sundials beyond a mere description thereof. These markings cannot be fully explained in terms of our present knowledge of Islamic gnomonics, but I anticipate that the publication of the repertory of Islamic astronomical instruments currently being prepared by A. Brieux and F. Maddison, which will include all known Islamic sundials,[3] will serve to revive some interest in a subject which has hardly progressed for several decades. Hence it seems worthwhile to present these sundials anew and to point out the various problems associated with each one.

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1. The research on medieval Islamic science conducted at the American Research Center in Egypt during the years 1972-80 was sponsored mainly by the Smithsonian Institution (1972-80), and also by the National Science Foundation, Washington, D. C. (1972-80) and the Ford Foundation (1976-79). This support is gratefully acknowledged.

The Cordova sundial was brought to my attention by my friend Dr. Lisa Golombek of the Royal Ontario Museum and the University of Toronto. A photograph of the sundial, together with information on its size and provenance, was kindly provided by Sra. Ana Maria Vicent Zaragosa, Director of the Museo Arqueológico Provincial in Cordova. The fact that the sundial had been published and the existence of the Almeria and Granada sundials came to my attention during an annual visit to the Sterling Library at Yale University in the spring of 1978. A photograph of the Tunisian sundial from the archives of Mr. Francis Maddison, Curator of the Museum of History of Science, Oxford, was kindly provided by M. Alain Brieux of Paris. A photograph of the Qayrawan sundial was kindly provided by Capt. René Rohr of Strasbourg. Prof. Owen Gingerich of Harvard University kindly obtained for me a microfilm of the *Libros del Saber* from Harvard University Library. Finally, it is a pleasure to record my gratitude to those libraries which have supplied me with microfilms of manuscripts in their collections, including the Egyptian National Library in Cairo, the Biblioteca de El Escorial; the Biblioteca Medicea-Laurenziana in Florence; and the British Library in London.

2. Each of the publications (*de los Santos* on the Cordova dial; *de Orús* on the Almeria dial; and *Cabanelas* on all three Andalusian dials) contains errors of interpretation, and none of them points out any of the defects of the dials. However, Cabanelas provided useful physical descriptions of each of the dials and put them in the context of earlier Greek sundials and the treatise on sundials in the *Libros del Saber*.

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King 1:	D. A. King, "A Fourteenth Century Tunisian Sundial for Regulating the Times of Muslim Prayer", in *Prismata: Festschrift für Willy Hartner*, eds. W. G. Saltzer and Y. Maeyama, (Wiesbaden, Franz Steiner Verlag, 1977), pp. 187-202.
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Luckey:	P. Luckey, "Thābit b. Qurra's Buch uber die ebenen Sonnenuhren", *Quellen und Studien zur Geschichte der Mathematik, Astronomie, und Physik*, Abt, B, Bd. 4 (1937-1938), 95-148.
Mayer:	L. A. Mayer, *Islamic Astrolabists and their Works* (Geneva, Albert Kundig, 1956).
Michel&Ben-Eli:	H. Michel, and A. Ben-Eli, "Un Cadran Solaire remarquable", *Ciel et Terre*, 81 (1965).
Nallino:	C. A. Nallino, *al-Battānī sive Albatenii Opus Astronomicum. (Pubblicazioni del Reale Osservatorio di Brera in Milano*, XL). 3 vols. (Milan and Rome, 1899-1907, reprinted Frankfurt Minerva G. m. b. H., 1969).
RCEA:	Et. Combe, J. Sauvaget, G. Wiet, *etc.*, *Repertoire Chronologique d'Epigraphie Arabe*, tôme 13, (Le Caire, 1944).
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Table 3

Coordonnées des positions respectives sur le cadran Ibn Ṭūlūn

(Ombre en mms., azimuts au degré le plus proche)

Heures	Solstice d'été				Solstice d'hiver			
	Côté gauche		Côté droit		Côté gauche		Côté droit	
	Ombre	Azimut	Ombre	Azimut	Ombre	Azimut	Ombre	Azimut
1	185	18° S	187	19° S	275	33° N	272	33° N
2	83	10 S	83	11 S	–	–	130	40 N
3	50	4 S	50	4 S	93	49 N	94	48 N
4	28	3 N	28	2 N	73	60 N	73	59 N
5	–	–	13	19 N	62	74 N	62	73 N
6	5	90 N	5	90 N	58	90 N	57	90 N
ᶜaṣr	–	–	50 ?	4 S		ᶜaṣr (original)	102	45½ N
						ᶜaṣr (corrigé)	105	44½ N

Equinoxes: Ombre de midi 26, ombre de l'ᶜaṣr 71½, azimut de l'ᶜaṣr 21½°

Table 2

Tables d'al-Maqsī pour un cadran horizontal à la latitude 30°

(MS Istanbul Nurosmaniye 2943, fol. 13v)

	Solstice d'été			Solstice d'hiver		
Heures	Hauteur	Azimut	Ombre	Hauteur	Azimut	Ombre
1	13;51° [0]	19;28° [—1] S	48;40 [—1]	9;21° [0]	34;16° [0]	72;[58?][2] [+1]
2	28;22 [0]	12;19 [0] S	22;14 [0]	17;54 [0]	42;13 [0]	37;9 [—1]
3	43;[15][1] [—1]	5;19 [+6!] S	12;45 [0]	25;20 [0]	51;41 [0]	25;21 [0]
4	58;20 [—1]	3;1 [—12] N	7;24 [0]	31;13 [—1]	62;56 [+1]	19;48 [+1]
5	73;13 [+1]	18;12 [—5] N	3;37 [0]	35;4 [0]	75;57 [+3]	17;6 [+1]
6	83;35 [0]	90;0 [0] N	1;21 [0]	36;25 [0]	90; 0 [0]	16;16 [0]
ᶜaṣr	41;58 [+1]	5;51 [—1] S	13;21 [0]	23;0 [0]	48;20 [0]	28;16 [0]

Equinoxes: Ombre de midi 6;56[0], ombre de l'ᶜaṣr 18;56[0], azimut de l'ᶜaṣr 21;28° [0]

1. Le MS Nurosmaniye porte 55 mais le MS Le Caire Dār al-Kutub *mīqāt* 955, fol. 9v, porte 15.
2. Nurosmaniye: 18, Le Caire: 13, exact: 57.

Table 1

Tables d'al-Marrākushī pour un cadran horizontal à la latitude 30°

(MS Paris B. N. ar. 2507, fols. 123v and 137r)

	Solstice d'été			Solstice d'hiver		
Heures	Hauteur	Azimut	Ombre	Hauteur	Azimut	Ombre
1	13;51° [0]	19;28° [—1] S	48;40 [— 1]	9;21° [0]	34;14° [—2 N]	72;53 [—4]
2	28;21 [— 1]	12;19 [0] S	22;15 [+ 1]	17;53 [— 1]	42;14 [+1 N]	37;10 [0]
3	43;15 [— 1]	5;13 [0] S	12;45 [0]	25;20 [0]	51;40 [—1 N]	25;21 [0]
4	58;22 [+ 1]	3;16 [+3] N	7;24 [0]	31;15 [+ 1]	62;55 [0 N]	19;48 [+1]
5	73; 8 [— 4]	18;12 [—5] N	3;38 [+ 1]	35;5 [+ 1]	75;53 [—1 N]	17;5 [0]
6	83;35 [0]	90;0 [0] N	1;21 [0]	36;25 [0]	90;0 [0 N]	16;16 [0]
ᶜaṣr	41;58 [+ 1]	5;52 [0] S	13;21 [0]	23;0 [0]	48;20 [0 N]	28;16 [0]

Equinoxes: Ombre de midi 6;56 [0], ombre de l'ᶜ*aṣr* 18;17 [devrait être 18;56!], azimut de l'ᶜ*aṣr* 21;14° [— 14] S

un dessin (voir Pl. 5). Ce cadran comporte un demi-cadran à droite qui montre le temps écoulé depuis le lever du soleil (et du même coup le temps qui reste à courir jusqu'à midi et à la prière qui y est associée, le *ẓuhr*). Les courbes des heures sont dessinées pour chaque dix degrés équinoxiaux et les valeurs sont indiquées sur la courbe du Cancer comme suit: 20°, 30°, . . ., 100° (le maximum pour la latitude 30° est environ 104½°). Le demi-cadran à gauche montre les degrés qui restent jusqu'à l'*ᶜaṣr* comme suit: 50°, 40°, 30°, 20°, 10°, puis la courbe de l'*ᶜaṣr* même, puis les degrés qui restent jusqu'au coucher du soleil (et à la prière du *maghrib*) comme suit: 50°, 40°, 30°, 20°. Voici donc un cadran bien utile pour la mosquée, qui sert à montrer le temps qui reste à courir jusqu'aux temps des trois prières: *ẓuhr*, *ᶜaṣr*, et *maghrib*.

APPENDICE

Additions et Corrections à *Janin & King*

1. Nous avons omis de souligner le fait, d'ailleurs évident, que lorsqu'Ibn al-Shāṭir explique qu'il regarde l'extrémité de la boussole par le trou dans le couvercle de la boîte, il ignore la déclinaison magnétique. Un siècle plus tard, ainsi que nous l'avons remarqué, al-Wafā'ī suggérait une correction de 7° pour en tenir compte.

2. Nous préparions notre description et usage du cadran polaire universel dans l'instrument d'Ibn al-Shāṭir, lorsque nous avons eu connaissance d'une illustration et d'une description dans *Michel et Ben Eli*, d'un cadran polaire pour une latitude déterminée construit à Acre en 1786-87. Nous reproduisons l'illustration dans la Pl. 6. Notez qu'il n'y a pas de courbe pour l'*ᶜaṣr*; on aurait pu en dessiner une pour la latitude locale, mais elle n'aurait pas pu servir pour d'autres latitudes. Il n'est pas exact de dire, avec Michel, que le cadran d'Acre était surtout destiné à régulariser les heures de prières. Nous ne connaissons pas d'autre cadran polaire dans le monde de l'Islam.

3. L'autre instrument décrit par al-Wafā'ī, appelé *al-muqawwar* et mentionné p. 217 note 11, est en fait une armille équatoriale comme le *dā'irat al-muᶜaddil*: mais les differentes parties se replient et peuvent être conservées dans la boîte ronde avec couvercle qui forme la base de l'instrument. Il résulte du traité d'al-Wafā'ī sur cet instrument que c'était une production antérieure à celle du *dā'irat al-muᶜaddil*: il ne mentionne pas, par exemple, la déclinaison magnétique, se contentant de dire que l'aiguille de la boussole a sa direction "près du méridien". Dans un article précédent nous avons comparé le *Ṣandūq al-yawāqīt* d'Ibn al-Shāṭir avec le *dā'irat al-muᶜaddil* d'al-Wafā'ī: *al-muqawwar* d'al-Wafā'ī constitue un échelon intermédiaire de développement et confirme notre impression qu'al-Wafā'ī s'était inspiré du *Ṣandūq al-yawāqīt* d'Ibn al-Shāṭir.

4. A la p. 213 lisez *samkarahu* au lieu de *mubkiruhu*.

que Marcel avait à sa disposition, les renseignements qui découlent de ces mesures sont assez surprenants.

En général les dessins du cadran que nous avons examinés semblent être assez exactement disposés, mais deux exceptions sont la courbe de l'*ᶜaṣr* et le tracé du solstice d'hiver. La branche gauche inférieure de la courbe de l'*ᶜaṣr* a été visiblement ajoutée plus tard pour essayer de rectifier la courbe originale de l'*ᶜaṣr*. De plus, l'erreur de la courbe originale de l'*ᶜaṣr* près du tracé du solstice d'hiver apparaît bien provenir d'une erreur dans la position de l'intersection du dit tracé avec le méridien. Si nous ajoutons la longueur du gnomon à la distance sur le méridien entre le pied du gnomon et le tracé du solstice d'hiver, nous obtenons la distance entre le pied du gnomon et l'intersection de la courbe originale de l'*ᶜaṣr* avec le tracé. Celui qui a dessiné la courbe corrigée de l'*ᶜaṣr* s'est arrangé pour que l'ombre de l'*ᶜaṣr* au solstice d'hiver ait une longueur correcte, mais l'erreur dans le tracé du solstice d'hiver sur le cadran entre la neuvième heure et la onzième, resultant probablement d'une erreur dans la position de la marque de la dixième heure au solstice, rendait impossible d'obtenir en même temps l'azimut correct pour l'*ᶜaṣr*. Etant donné que la fonction la plus importante d'un cadran de mosquée est l'indication du temps des prières, on ne peut pas dire que le constructeur de ce cadran ait remporté un plein succès! Peut-être, d'ailleurs, avons nous mis le doigt sur la raison de la destruction de ce cadran, brisé en plusieurs morceaux.

Enfin, nous remarquons que le seul autre exemple d'un cadran fait de deux demi-cadrans superposés que nous connaissions se trouve dans un traité sur la gnomonique par le *muwaqqit* égyptien Ibn al-Muhallabī, écrit au Caire en 829 H. = 1425—26 J. C.[6] Ce traité existe dans un beau manuscrit unique conservé à la Bibliothèque de Chester Beatty à Dublin, numeroté 3641 et copié à Alexandrie en 858 H = 1455 J. C. Ibn al-Muhallabī commence son traité par un éloge d'al-Maqsī, en ajoutant que le lecteur qui veut en savoir plus que ce qu'il va exposer dans son traité doit se tourner vers le compendium d'al-Marrākushī. Puis Ibn al-Muhallabī presente de nouvelles tables (voir Pl. 4) et de nouveaux dessins pour construire les cadrans horizontaux, verticaux, et inclinés, tous calculés pour la latitude du Caire, 30°. Parmi ces textes on trouve des tables pour tracer un cadran à deux moitiés avec

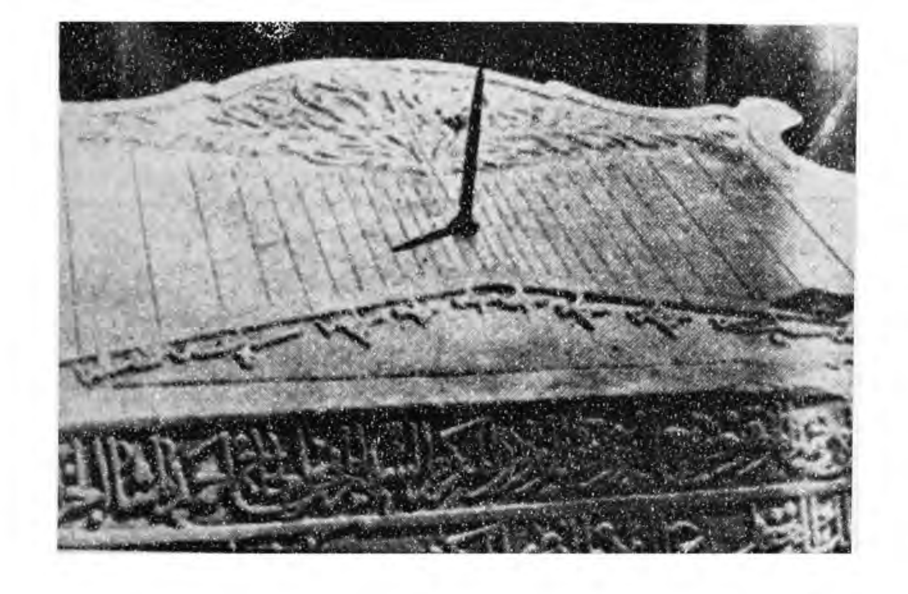
6. Si n est la distance requise en mms, nous avons, du fait que la distance méridienne entre les tracés des deux solstices est 52 mms, et que les ombres solsticiales sont 1;21 et 16;16 unités, que

$$\frac{n+52}{n} = \frac{16;16}{1;21} \approx 12 \quad ,$$

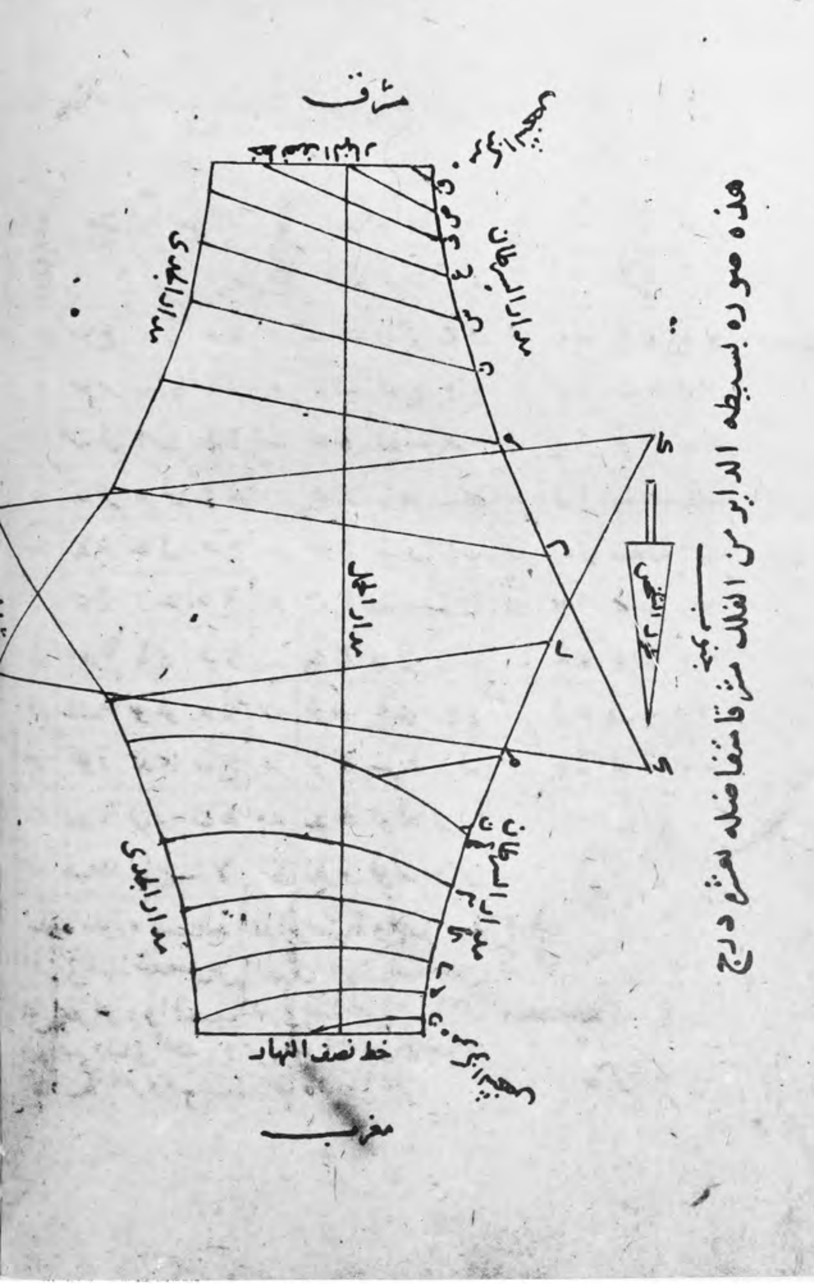
d'où

$$n + 52 = 12\,n \quad \text{et} \quad n \approx 5 \text{ mm.}$$

7. Ibn al-Muhallabī n'est mentionné dans aucun travail moderne sur la science islamique et on ne lui connait aucun autre ouvrage scientifique.



Pl. 6: Le cadran polaire d'Acre. *(photo Abumax)*

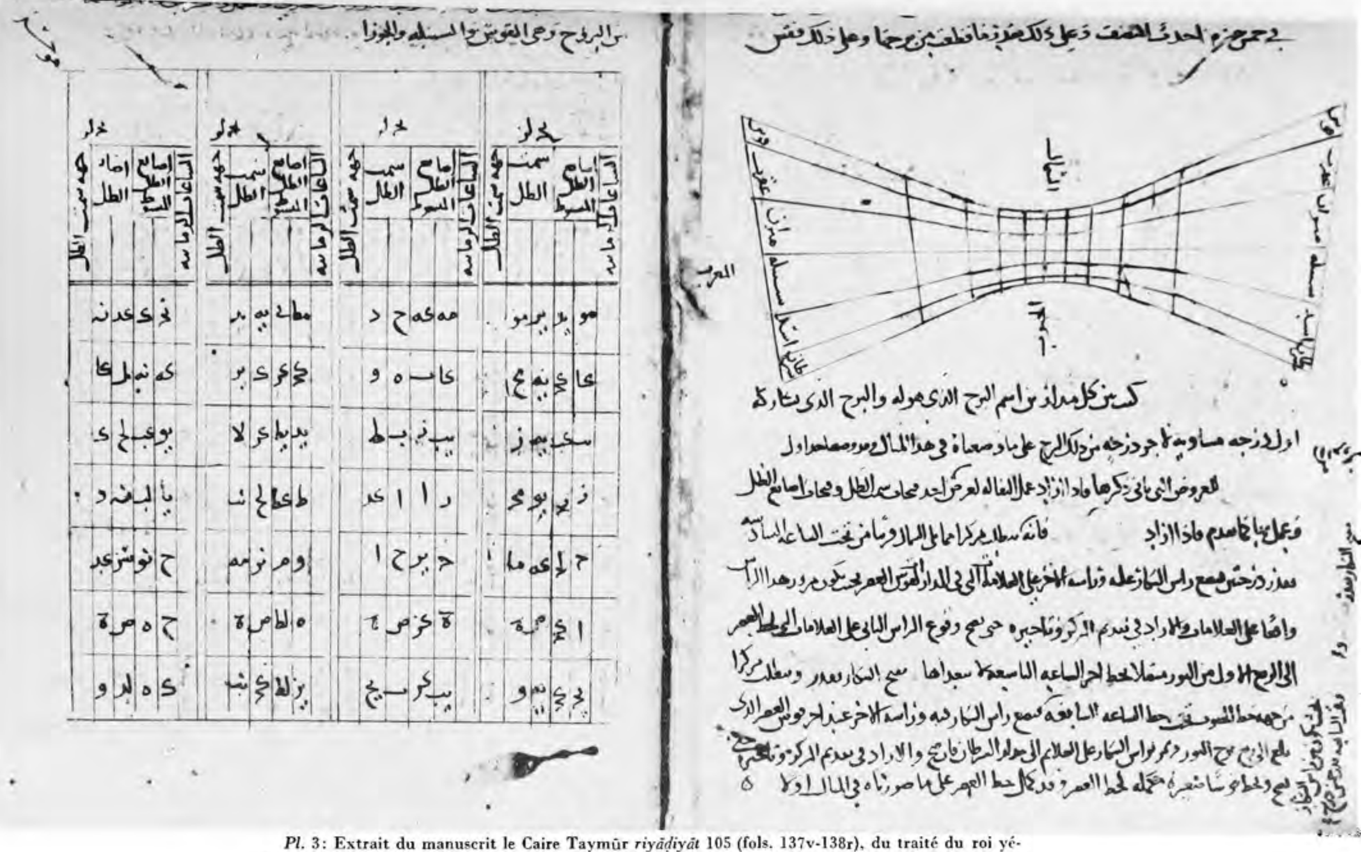


Pl. 5: Extrait du manuscrit Chester Beatty no. 3641 (fol. 11v), qui montre le cadran à deux moitiés d'Ibn al-Muhallabī, qui sert à indiquer le temps qui reste jusqu'aux trois prières du *ẓuhr*, *ᶜaṣr*, et *maghrib*.

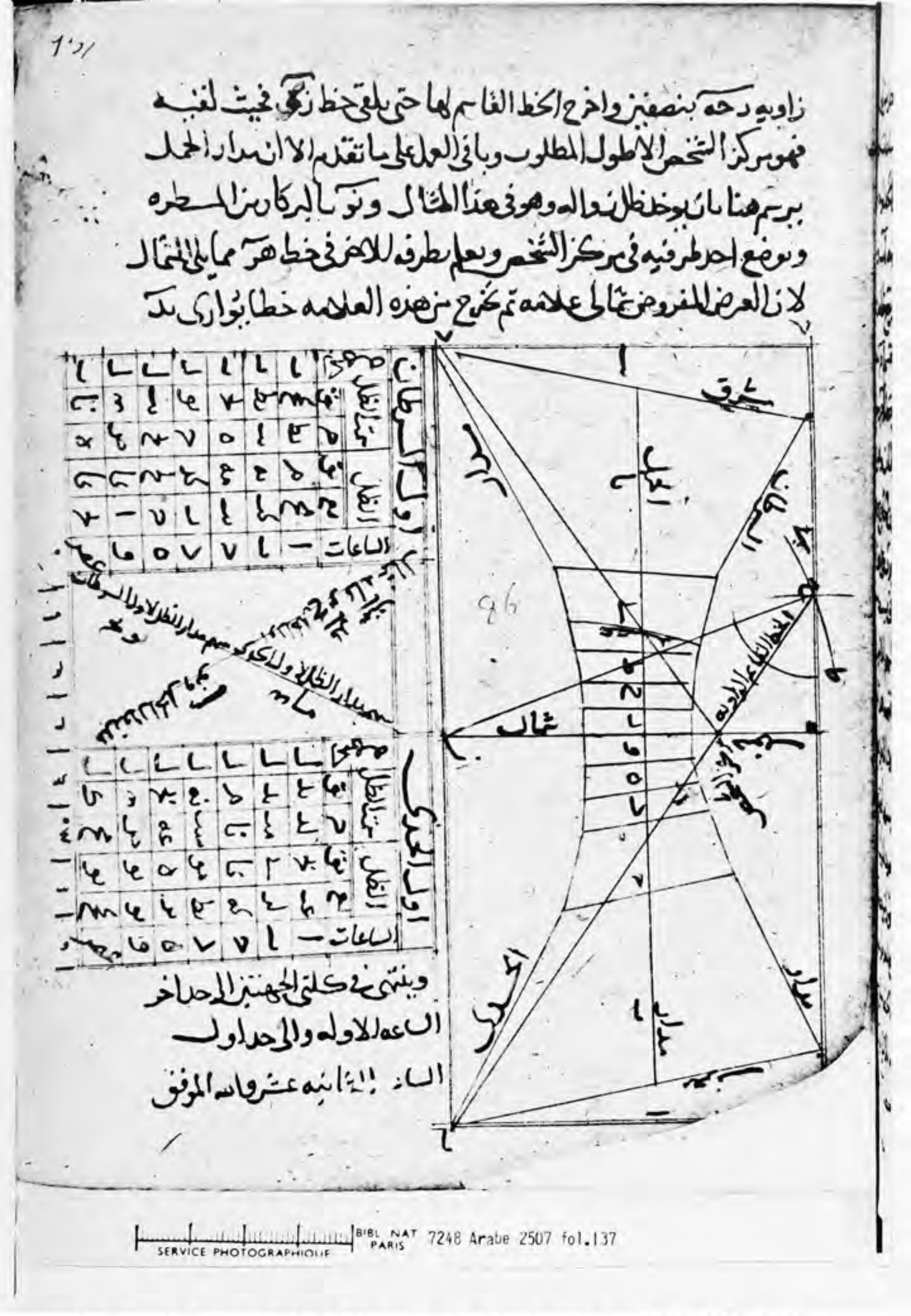
جدول فيّ الباقي للعصر الموضوعة في السطح الموازي

بسيطة الدائر من الفلك مشرقا

Pl. 4: Extrait du manuscrit Dublin Chester Beatty no. 3641 (fols. 10v et 11r), qui montre les tables avec lesquelles on pourrait dessiner le cadran illustré en Pl. 5. A droite on voit les tables qui donnent la hauteur du soleil, son azimuth, et la longueur de l'ombre d'un style de 12 unités, le tout calculé pour chaque 5° de temps écoulé jusqu'au milieu du jour pour les deux solstices. A gauche on voit les trois mêmes quantités calculées pour chaque 5° avant l'*ʿaṣr* pour les deux solstices et les equinoxes.

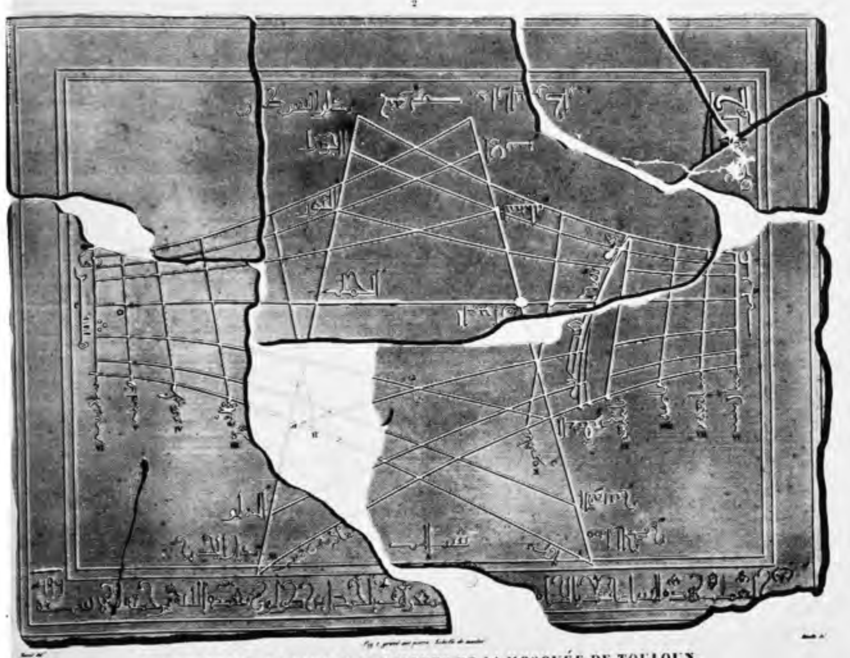


Pl. 3: Extrait du manuscrit le Caire Taymūr *riyāḍiyāt* 105 (fols. 137v-138r), du traité du roi yémenite al-Ashraf, qui montre le dessin d'un cadran aux heures temporaires pour la latitude de Taiz (13;37°), et les tables qui servent à le tracer. On remarque que le pied du gnomon se trouve entre la courbe du solstice d'été et la droite des équinoxes, et que la courbe de l'ʿaṣr montre un discontinuité


زاويه د ح ه بنصفين واخرج الخط القاسم لها حتى يلقى خط ز ح فحيث لقيه
فهو مركز الشخص الاطول المطلوب وباقي العمل على ما تقدم الا ان مدار الحمل
يرسم هنا بانه خط ظل نهاره وهو في هذا المثال
ونضع احد طرفيه في مركز الشخص ونعلم بطرفه الاخر في خط هر مما يلي الشمال
لان العرض المفروض شمالي علامه ثم نخرج من هذه العلامه خطا يوازي ند

وينتهي في كلتي الجهتين الى حد اخر
الساعه الاولى والى حد اول
الساعه الثانيه عشر والله الموفق

Pl. **2: Extrait du manuscrit Paris B.N. ar. 2507 (fol. 137r) du traité de Abū ʿAlī al-Marrākushī, qui montre le dessin d'un cadran aux heures temporaires pour la latitude du Caire, et les tables qui servent à le tracer.**



Pl. 1: Le cadran solaire de la Mosquée d'Ibn Ṭūlūn, reproduit par M. Marcel, et inseré comme illustration dans la *Description de l'Egypte.*

référer à Ibn al-Shāṭir ni à aucun autre astronome syrien.

Examinons maintenant les tables d'al-Marrākushī (Pl. 2) et d'al-Maqsī pour un cadran horizontal donnant les heures temporaires pour la latitude du Caire, retenue pour 30;0° avec une obliquité de 23;35°. Ces deux tables sont reproduites dans les Tableaux 1 et 2[4] et il apparaît probable qu'elles ont été calculées indépendamment. Les valeurs ont été recalculées avec le calculateur électronique de l'Université Américaine du Caire,[5] et pour chaque valeur des tables d'origine l'erreur dans le deuxième chiffre sexagésimal, c'est-à-dire dans les minutes, est donnée entre crochets, calculée selon la convention:

erreur = texte — valeur exacte

Les deux tables sont assez exactement calculées, bien que chacune comporte quelques erreurs qui auraient dû surprendre leurs calculateurs. Néanmoins les erreurs dans les coordonnées de l'ᶜ*aṣr* chez al-Marrākushī pour les équinoxes sont bien moins graves que celles qui ont produit la branche inférieure droite de la courbe de l'ᶜ*aṣr* sur notre cadran.

Le Tableau 3 montre les coordonnées correspondant aux positions solsticiales et équinoxiales du cadran d'Ibn Ṭūlūn, basées sur les mesures prises sur la planche de la *Description de l'Egypte*. Pour obtenir ces coordonnées on a d'abord calculé que les pieds des deux gnomons étaient à une distance d'environ 5 mms. au nord de l'intersection des meridiens et du tracé du solstice d'été.[5] Si l'on tient compte du caractère fragmentaire du cadran

4. La table d'al-Marrākushī se trouve déjà dans *Sédillot-père*, II, pp. 454 and 491.

5. Le processus trigonométrique pour le calcul de ces tables est le suivant. Nous posons la latitude locale φ, l'obliquité ε, la longitude du soleil λ. Nous calculons la déclinaison δ solaire par la formule

$$\sin \delta = \sin \varepsilon \sin \lambda ,$$

et l'équation du jour d par la formule

$$\sin d = \tan \delta \tan \varphi .$$

Ensuite la longueur d'une heure de jour temporaire t se déduit de la demi-longueur du jour D par la formule

$$t = \frac{D}{6} = \frac{90^\circ + d}{6} .$$

La hauteur du soleil h correspondant à une angle horaire égal à un multiple n de cette heure temporaire est alors fournie par la formule

$$\sin h = \sin \delta \sin \varphi + \cos \delta \cos \varphi \cos (nt)$$

et la longueur de l'ombre correspondante s pour un gnomon de longueur 12 est alors

$$s = 12 \cot h.$$

Pour trouver l'azimut a nous utilisons la formule

$$\sin a = \frac{\sin h \sin \varphi - \sin \delta}{\cos h \cos \varphi}$$

Les procédés mediévaux étaient mathématiquement equivalents aux procédés ci-dessus. Ils étaient déjà connus des astronomes musulmans au début du neuvième siècle, venant de sources indiennes où ils étaient déduits des projections orthogonales de la sphère celeste. Etant donné que ces déductions n'exigent aucune connaissance de trigonométrie sphérique, il est regrettable que bien des auteurs modernes pensent que les anciens astronomes musulmans qui ont utilisé ces formules devaient nécessairement connaître la formule du cosinus de la trigonométrie sphérique (voir, par exemple, tout récemment, *Sezgin*, V, pp. 35 et 261).

Moyen Age aussi comme la latitude du milieu de 4e climat.[7]

On ne peut pas encore tracer le dévelopement des tables islamiques depuis l'époque Abbasside jusqu'à l'époque d'al-Marrākushī, d'al-Maqsī et du cadran Ibn Ṭūlūn, mais les matériaux ne manquent pas pour les recherches futures. Il existe enfin des douzaines de manuscrits arabes et turcs dont la plupart sont de provenance égyptienne, syrienne et turque, qui traitent de la gnomonique et présentent des tables, mais qui n'ont encore jamais été etudiés.[8] (Curieusement on ne trouve presque rien en langue persane.) Toutes les tables qu'on trouve dans ces traités sur la gnomonique représentent une tradition islamique consistant à préparer des tables presque pour le seul plaisir de préparer des tables! Il est déjà évident dans leurs compilations sur d'autres chapitres de l'astronomie que les astronomes musulmans avaient une véritable passion pour le calcul des tables.[9]

IV. Analyse des dessins du cadran d'Ibn Ṭūlūn

Ni les tables d'al-Marrākushī, ni celles d'al-Maqsī ne donnent les coordonnées pour chaque signe du zodiaque, telles qu'elles auraient été nécessaires pour construire le cadran d'Ibn Ṭūlūn. De plus nous n'avons pas d'autres tables égyptiennes de cadrans solaires remontant au treizième siècle ou aux siècles précédents. En fait les seules tables connues de cadrans solaires islamiques remontant au treizième siècle et qui donnent les coordonnées pour chaque signe, sont celles qui ont été établies pour differentes latitudes dans le Yémen et le Hedjaz par le Sultan du Yémen al-Ashraf, dans son traité sur l'astrolabe, le cadran horizontal et la boussole magnétique, écrit aux environs de 1295.[1] Le Sultan al-Ashraf connaissait l'ouvrage d'al-Marrākushī écrit à peine quinze ans plus tôt. Un extrait de ses tables de cadrans, montrant des tables calculées expressément pour la latitude de Taiz retenue pour 13;37°, est reproduit dans Pl. 3. On ne connait pas de tables pour cadrans aussi detaillées depuis le quatorzième siècle, bien que le cadran d'Ibn al-Shāṭir construit pour la Mosquée Umayyade de Damas porte le tracé des ombres pour chaque signe du zodiaque,[2] et qu'Ibn al-Shāṭir ait très probablement construit son cadran en utilisant des tables qu'il avait preparées à l'avance. L'astronome syrien du quinzième siècle al-Tīzīnī a dressé un jeu detaillé de tables de cadrans et presenté son travail comme une extension du traité d'al-Maqsī,[3] sans se

7. Voir *Nallino*, II, pp. 188 et 295-296.

8. Une exception est le traité (avec tables) de Sibt al-Māridīnī (*Suter*, no. 445) qui a été étudié dans *Schoy* 2.

9. Voir *Kennedy* sur les manuels astronomiques appelés *zījes* et *King* 3, spécialement pp. 51-53 et 56, où l'on traite des tables pour construire les cadrans solaires.

1. Sur le Sultan al-Ashraf voir *Suter*, no. 394. Son traité se trouve dans le MS Le Caire Taymūr *riyāḍa* 105 (149 fols., *ca.* 695H), et il paraît qu'il y en a une autre copie à Téhéran. Une table qui donne la hauteur l'azimuth du soleil pour chaque heure temporaire et chaque signe du zodiaque, calculée pour la latitude du Caire, se trouve dans la traité sur les cadrans du célèbre Ibn al-Haytham (*fl.* le Caire, *c.* 1025 J. C.), dont nous avons examiné le MS Teheran Majlis-i-Shūrā 39341,1 (11 fols., *ca.* 1000H). Dans ce manuscrit tous les chiffres manquent dans la table, et nous n'avons pas eu l'occasion de consulter d'autres manuscrits de cette oeuvre.

2. *Cf.* l'illustration dans l'étude citée dans la note 3 de la Section 1.

3. Sur al-Tīzīnī voir *Suter*, no. 450. Ses tables se trouvent dans le MS Vatican Borg. 105,3 (fols. 20r-38v, *ca.* 900H), texte apparemment unique.

française par J.-J. Sédillot,[2] toute la théorie mathématique et en outre des tables pour construire les cadrans horizontaux, verticaux, et inclinés à la fois sur le méridien et sur le premier vertical. Al-Marrākushī donne aussi des tables pour construire ces cadrans à la latitude du Caire, 30°, où il travaillait quelques années avant la construction du cadran Ibn Ṭūlūn, car il a daté son traité de 1280 J. C.[3] Voir en Pl. 2 ses tables et son dessin pour un cadran horizontal préparé pour cette latitude.

Il y a un autre traité égyptien sur les cadrans qui date de la même époque que celui d'al-Marrākushī et qui n'avait jamais été étudié jusqu'à il y a quelques années. Ce nouveau traité qui a été préparé par l'astronome égyptien al-Maqsī en 1277 J. C., soit un peu avant le traité d'al-Marrākushī, contient plus de cent tables pour construire les cadrans à la latitude du Caire, 30°.[4] Ce qui rend les tables d'al-Maqsī plus complètes que celles d'al-Marrākushī, c'est qu'il calcule une table pour les cadrans verticaux inclinés sur le méridien pour chaque degré de l'inclinaison. Où est-ce qu'on doit chercher l'origine de ces tables Islamiques pour les cadrans?

Il a été découvert en 1974 un traité sur les cadrans attribué à al-Khwārizmī (*fl.* Baghdad, *ca.* 830 J. C.).[5] Ce traité existe dans un manuscrit précieux à Istanbul; il consiste en une courte introduction et en plusieurs tables qui donnent pour douze latitudes différentes entre 0° et 40° la hauteur du soleil, son azimut et la longueur de l'ombre d'un style de 12 unités pour chaque heure temporaire. Il ya des tables additionelles pour les latitudes de Samarra et Baghdad, et la valeur de l'obliquité employée est 23;51° (employée par al-Khwārizmī dans ses tables astronomiques). En 1976 quelques unes de ces tables ont été trouvées ajoutées au traité sur les astrolabes extraordinaires d'al-Sijzī (*fl.* Iran, *ca.* 950 J. C.), conservé dans un autre manuscrit précieux à Istanbul.[6] D'autres tables de cette sorte existent dans les sources manuscrites. Dans le manuscrit unique du texte arabe du manuel astronomique (*zīj*) de l'astronome Syrien al-Battānī (*fl.* Raqqa, environ 910 J. C.). C. A. Nallino, qui a publié ce *zīj*, a trouvé, parmi quelques tables qui ne doivent pas appartenir au travail original d'al-Battānī, deux petites tables qui donnent la hauteur du soleil et son azimut pour chaque heure temporaire, calculés pour la latitude 36°, employée par al-Battānī pour Raqqa et acceptée au

2. *Sédillot-père* présente une traduction de la premiere moitié du traité dans lequel on trouve une discussion de la gnomonique. *Sédillot-fils* offre un sommaire assez mal présenté de la deuxieme moitié du traité.

3. Voir *Sédillot-père*, pp. 136-137 et 276. J.-J. Sédillot a faussement daté al-Marràkushī à 1230 J. C. (voir *Sédillot-père*, I, pp. 13-14) et n'a nulle part mentionné qu'il travaillait au Caire.

4. Sur al-Maqsī voir *Suter*, no. 383.

5. Sur al-Khwārizmī voir l'article de G. J. Toomer dans *DSB*. Son traité sur les cadrans se trouve dans MS Istanbul Aya Sofia 4830, fols. 231v-235r, copié 626H/1228-29 à Damas.

6. Sur ce traité voir *Sezgin*, V, p. 334, no. 34.

une deuxième courbe de l'^{c}*aṣr* fut tracée à sa gauche. C'est nettement le cas pour les déclinaisons septentrionales (partie inférieure de la courbe); pour les déclinaisons meridionales, il est impossible de distinguer entre les deux branches. Notre hypothèse se base sur le fait que la branche inférieure droite de la courbe de l'^{c}*aṣr* est effectivement fautive et que la branche inférieure gauche est plus correctement disposée (voir Section IV).

Bien qu'il soit beaucoup plus récent (696 H = 1296 J. C.) que la mosquée à laquelle il était destiné (elle fut construite en 259 H = 872 J. C.), ce cadran est le plus ancien des cadrans solaires musulmans du Caire qu'on connaît aujourd'hui. Son dessin, nous l'avons vu, est original. La gravure est d'une exécution parfaite. Ses inscriptions sont d'une ecriture très rare: elles sont en caractères karmatiques de la forme la plus élégante; les points diacritiques y sont fidèlement indiqués. A tous ces titres et bien que nous ne le connaissions que par une reproduction, heureusement très exacte, le cadran solaire qui ornait jadis la Mosquée d'Ibn Ṭūlūn était une pièce splendide, au moins à première vue.

III. Sur les tables employées par les astronomes arabes pour la construction des cadrans

En considérant les nombreux traités sur les cadrans écrits par des savants arabes aux premiers siècles de l'Islam et la pléthore de tels traités (écrits principalement en Egypte, Syrie, et Turquie) dans les six derniers siècles, on voit que le petit nombre des cadrans qui subsistent ne représente point l'intensité de l'activité musulmane dans ce domaine. On connait l'existence de traités sur les cadrans, dont la plupart sont perdus, préparés par plusieurs astronomes arabes dès l'époque Abbasside (spécialement au neuvième siècle).

Le plus complet parmi les documents les plus anciens qui nous sont connus à l'heure actuelle est une remarquable étude sur les cadrans plans qui émane de Thābit b. Qurra, philosophe, médecin, mathématicien, et traducteur, (*fl.* Baghdad, *ca.* 900 J. C.). Ce traité, publié et traduit par K. Garbers et analysé par P. Luckey,[1] expose la théorie géométrique de toutes les sortes de cadrans plats, d'une manière très rationnelle et très détaillée, précisant les formules diverses utilisées pour le calcul et la construction de ces cadrans, qu'ils soient horizontaux, verticaux, méridionaux, ou déclinants, orientaux ou occidentaux, ou inclinés et déclinants. Mais ce traité ne contient pas de tables.On trouve aussi dans le compendium de l'astronome arabe du treizième siècle Abū ^{c}Alī al-Marrākushī et dans la moitié qui a été publiée en traduction

1. Voir *Garbers* et *Luckey*. Une autre très importante étude sur la gnomonique arabe est la thèse de P. Luckey citée dans *Sezgin*, V, p. 294.

n'a rien à faire avec un tel cadran, nous pensons qu'il faut lire: *ṭūl al-miqyās*, c'est-à-dire, "longueur du style", ou bien, *ṭūl al-miqyāsayn*, c'est-à-dire, "longueur des deux styles". Nous croyons de plus qu'à côté de cette inscription on trouvait jadis un trait de la même longueur, qui manque sur le dessin de Marcel à cause des fractures du cadran.

Les 4 points cardinaux sont marqués: Nord A, Sud E, Est C, Ouest D. Les 2 styles identiques et perpendiculaires à la table étaient placés au sud de la petite échelle ouvrant chaque moitié; ils avaient leur pied en des points qui n'ont pu être relevés, car les styles avaient été arrachés en même temps qu'avaient été cassées les parties correspondantes de la dalle.

Chaque moitié du cadran comporte les lignes des signes: sur la partie Est sont inscrites la droite des équinoxes (Balance 7) et les hyperboles d'entrées dans les signes (Ecrevisse 4, Lion 5, Vièrge 6, Scorpion 8, Sagittaire 9, Capricorne 10). Sur la partie Ouest sont également inscrites la droite des équinoxes (Bélier 1) et les hyperboles d'entrées (Taureau 2, Gémeaux 3, Ecrevisse 4, Capricorne 10, Verseau 11, Poissons 12).

Les heures marquées sont, selon l'usage ancien, les heures "temporaires", qui représentent la douzième partie de la durée du jour; les "heures" d'été sont ainsi plus longues que les "heures" des équinoxes (heures astronomiques), elles-mêmes plus longues que les "heures" d'hiver. Elles sont indiquées par des droites plus ou moins inclinées et qui sont numérotées, du matin au soir: la première I (il faut comprendre fin de la première heure), la deuxième II. . . , la sixième VI (midi), la septième VII. . . la onzième XI. Les heures du lever et du coucher du soleil ne peuvent pas être indiquées, le rayon horizontal du soleil rejetant alors à l'infini l'ombre des styles.

Entre la 9ᵉ et la 10ᵉ heure, sur la moitié Ouest du cadran l'inscription *qaws al-ᶜaṣr*, c'est a dire, "courbe de l'ᶜ*aṣr*" se refère à l'heure à laquelle, selon la date, doit être récitée la prière de l'ᶜ*aṣr*, une des cinq prières obligatoires de l'Islam. D'après l'opinion dominante, l'heure de l'ᶜ*aṣr* intervient dans l'après-midi, lorsque l'ombre du style est égale à son ombre méridienne augmentée de la longueur du style.

Afin de prevenir le fidèle que l'heure de l'ᶜ*aṣr* approche, une plage sans gravure est ménagée sur la partie ouest du cadran, a partir de la droite de la 9ᵉ heure. Il est alors plus facile de voir exactement où se trouve la pointe de l'ombre et d'apprécier le temps restant à courir jusqu'a l'ᶜ*aṣr*. Mais en regardant de près la courbe de l'ᶜ*aṣr* on constate qu'elle parait avoir été dessinée en double, très nettement dans sa moitié nord, moins nettement dans sa moitié sud; quelle courbe faut il retenir?

La raison de cette double courbe de l'ᶜ*aṣr* semble être que la courbe originale de l'ᶜ*aṣr*, qui borde l'espace libre, s'est révelée fautive et qu'alors

M. Marcel ont été rapportées d'Egypte et le dessin du cadran solaire qu'elles représentent se trouve reproduit dans *l'Atlas de la Description de l'Egypte*, cet ensemble monumental contenant les rapports de tous les savants chargés de mission et dont on peut dire qu'il a "lancé" l'égyptologie.

Car il s'agit bien d'un cadran solaire, comme le laissent supposer les inscriptions. A première vue, la complexité (Pl. 1) est grande: deux gerbes de 7 branches, maintenues par des sortes de liens, partent des deux côtés de la dalle et s'élancent l'une vers l'autre en s'entrecroisant; partout des inscriptions qui semblent se mélanger et dont il faut retrouver l'application.

Mais pour qui a l'habitude des cadrans solaires musulmans, il apparaît bientôt que le dessin représente en fait deux moitiés d'un seul cadran, imbriquées l'une dans l'autre. Si l'on fait glisser par exemple la gerbe de droite vers la gauche jusqu'à ce que coincident les deux échelles les plus petites (ou inversement la gerbe de gauche vers la droite, *etc.*), on reconstitue le dessin connu d'un cadran solaire horizontal ordinaire (Pls. 2 et 3). Alors que chaque moitié du cadran avait son style particulier, la translation ci-dessus effectuée a fait coincider les deux styles en un seul, qui gouverne l'ensemble du cadran reconstitué.

Pourquoi l'auteur de ce cadran a-t-il adopté la complication des deux demi-cadrans? Il faut d'abord reconnaître que ce dessin, avec ses courbes, droites et inscriptions enchevêtrées, mais disposées selon un plan facile à retrouver, répond bien à la recherche géométrique et ornementale chère aux dessinateurs musulmans. La conception de ce dessin semble d'ailleurs être originale, car nous ne connaissons qu'un autre exemple d'une representation analogue (voir ci-dessous). En outre le procédé retenu permet de réduire considérablement l'encombrement du cadran.

L'inscription gravée sur le bord inférieur de la dalle indique:

.... (؟) لعمل هذه الساعات بالجا[مع]... (؟) [ا]لمعروف
باحمد بن طولون تغمده الله برحمته فى (؟) سنة ٦٩٦

c'est-à-dire:

. . . (?) pour faire (?) ces heures dans la mosquée
. . . (?) connue par (le nom de) Aḥmad ibn Ṭūlūn – que Dieu le protège avec Sa grace – dans (?) l'an 696H (= 1296-97 J. C.)

Dans le coin droit supérieur se trouve une autre inscription qui ne se laisse pas très bien lire. Marcel et Sédillot ont cru y lire: *ṭūl al-Miṣrayn n-h*, c'est à dire, "longitude des deux *Miṣrs*: 55°". Considérant que le longitude

premier auteur commence par un description du cadran (Section II) et le deuxième continue par une discussion des methodes employées par les astronomes musulmans pour construire les cadrans solaires (Section III), et une analyse mathématique des dessins du cadran de la Mosquée d'Ibn Ṭūlūn comparés avec les tables préparées par les astronomes égyptiens à l'époque Mamelouke (Section IV).

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II. Historique et description du cadran

Décidée en 1798 par le gouvernement du Directoire, l'expedition d'Egypte comportait, outre les moyens militaires placés sous le commandement du général Bonaparte, un nombre important de savants et de techniciens appartenant aux disciplines les plus diverses, qui reçevaient la mission de se consacrer à l'étude de l'Egypte et de sa civilisation. Parmi les bénéficiaires de cette initiative se trouvait M. J. J. Marcel, ancien directeur de l'imprimerie royale, grand spécialiste des langues orientales et de leurs écritures.

Dès son arrivée au Caire, M. Marcel se mit à dessiner et à reproduire toutes les inscriptions en langue arabe qu'il put relever sur les monuments, principalement sur les mosquées, écoles et tombeaux.

A la mosquée d'Ibn Ṭūlūn, l'une des plus anciennes du Caire, il découvrit, dans un pan de mur du minaret attenant à la mosquée, plusieurs fragments brisés d'une dalle de pierre, qui comportaient de nombreuses lignes, courbes et inscriptions gravées. Il rassembla aussitôt ces fragments qui reconstituèrent, à part quelques manquants peu importants, une dalle de 69 cm, sur 53 cm, laquelle faisait apparaître un quadrillage complexe mais harmonieux. M. Marcel s'empressa d'en tirer plusieurs exemplaires par les procédés typographiques, comptant bien emporter plus tard les fragments eux-mêmes; mais. . . dès le lendemain matin, ils avaient disparu! . . enlevés par quelqu'un qui avait pensé trouver là des objets de valeur, à en juger par les soins dont les entouraient des Français. . . Heureusement, les empreintes relevées par

Le Cadran Solaire de la Mosquée d'Ibn Ṭūlūn au Caire

L. Janin † et D. A. King*

I. Introduction

Depuis les recherches de Carl Schoy aux environs de 1920 sur la gnomonique arabe[1] les cadrans solaires musulmans ont été presque totalement ignorés par les historiens des sciences. Ce qui manque évidemment pour la documentation fondamentale sur la gnomonique arabe, ce sont des reproductions et des descriptions détaillées des plus importants cadrans solaires arabes.[2] L'un de nous a publié en 1972 une description d'un cadran magnifique du célèbre astronome Syrien du quatorzième siècle Ibn al-Shāṭir, cadran qui n'avait jamais été décrit dans la littérature moderne, bien qu'il soit sans doute le plus splendide de tous les cadrans arabes connus.[3] L'autre signataire a préparé plus récemment une description d'un cadran tunisien du quatorzième siècle qui a une importance spéciale pour notre connaissance des origines des définitions des prières musulmanes.[4] Le cadran que nous présentons ici, qui ornait jadis la Mosquée d'Ibn Ṭūlūn au Caire,[5] n'existe plus, mais il a été l'objet d'une très fidèle reproduction, parue dans la célèbre *Description de l'Egypte* préparée par les savants qui accompagnaient Bonaparte en Egypte.[6] De son côté L.A.M. Sédillot en a donné une description dans son "Mémoire sur les instruments astronomiques des Arabes" d'après le traité de l'astronome Abū ʿAlī al-Marrākushī, qui travaillait au Caire à la même époque que le constructeur du cadran de la Mosquée d'Ibn Ṭūlūn.[7] Nous considérons qu'il est interessant de présenter a nouveau ce beau cadran à la lumière des plus récentes recherches sur l'histoire de l'astronomie en Egypte médiévale.[8] Le

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1. Voir *Schoy* 1 et 2, et aussi Notes 1 et 2 à Section III.

2. Plusieurs des cadrans solaires musulmans qu'on connait sont indiqués dans *Mayer*. On s'attend a ce que la nouvelle édition que préparent M. Alain Brieux de Paris et Mr. Francis Maddison d'Oxford contiendra assez de nouvelles informations sur les cadrans pour susciter un renouveau d'interêt sur ce sujet.

3. *Janin*, reproduit en *Kennedy-Ghanem*, pp. 107-121.

4. *King* 1.

5. Voir *Wiet*, pls. 2-5 et pp. 100-101.

6. *Description de l'Egypte, Etat moderne, planches*, tome 11, planche c, et *Sédillot-fils*, pp. 25-26 et 56-58. Pour la documentation de l'inscription voir *RCEA*, no. 5023 à p. 157.

7. Voir *Sédillot-pere*, II, Pl. XVI, fig. 86.

8. Voir *King* 2 et les références citées.

We may well doubt that much would ever have come from Hunter's friend. Even more dubious is Tod's famous epitaph of Jayasiṃha himself:[90] "Three of his wives and several concubines ascended his funeral pyre, on which science expired with him." The "science" he supported never had a chance to develop in Sanskrit because no Indians were ever trained to utilize the observatories or the translations in a constructive manner, and because, whatever the results of Jayasiṃha's own observations may have been, they were not published in Sanskrit.

We have seen, therefore, that though a few elements of Islamic astronomy were adapted by Indian astronomers before the Moghul period, they were not allowed to affect in any way the structure of the traditional science. Moreover, though efforts were made to introduce various of the works emanating from the School of Samarqand to Sanskrit-reading astronomers in the seventeenth century, the translations met with hostility on the part of some, indifference from most, and, at best, an attempt to Indianize them on the part of a few; but these translations and adaptations contained nothing that would instruct the Indians regarding the reason for the claimed superiority of Islamic astronomy, which was its methodology involving both a reliance on carefully planned and executed observations and a concern with the cinematics of the planetary models. Finally Jayasiṃha's activities, while they resulted in Sanskrit translations of the *Almagest* and a few other works that could have taught this methodology to the Indians, were apparently completely ineffective; his original works in Sanskrit were not innovative, the translations themselves were ambiguous, and the main contribution of his school to astronomy, the *Zīj-i Muḥammad Shāhī* was addressed to a Persian rather than to a Sanskrit audience. Nityānanda, Kamalākara, Jayasiṃha and others may have recognized the superiority of Islamic over Indian astronomy, but they failed to find a way to persuade other Indian scientists of this fact, in part, I believe, because they did not themselves perceive wherein the superiority lay.

90. J. Tod. *Annals and Antiquities of Rajasthan* (repr. Oxford, 1920), vol. 3, p. 1356.

For he did, with his Persian experts, construct those five famous observatories. Jagannātha mentions these observatories and some of the results obtained at them, and some obtained by other astronomers at other observatories.[86] From this passage and from the *Zīj-i Muḥammad Shāhī* produced in the name of Jayasiṃha probably by Khayr Allāh Khān[87] we know that Jayasiṃha intended to follow the traditional method of Islamic astronomy in correcting astronomical parameters by careful observation, and that he hoped to improve the Islamic technique by simultaneously observing the same phenomena from five different localities. Though Jagannātha refers to some minor corrections to parameters like the obliquity of the ecliptic, it appears unlikely that the tables in the *Zīj-i Muḥammad Shāhī* are very different from those in the *Zīj* of Ulugh Beg; but no detailed study of Jayasiṃha's zīj has yet been made, so that we cannot decisively deny real significance to his work. However, the description of them given by Hunter in 1797[88] makes it clear that the structure of the tables is entirely Islamic. We do have for comparison, in Sanskrit, two works attributed to Jayasiṃha: a *Jayavinodasāriṇī* written in 1735, which contains tables for constructing the traditional Indian calendars, and a *Yantrarājaracanā*, a conventional Sanskrit treatise on the astrolabe. Neither work shows any trace of a new approach to astronomy . Moreover, other Sanskrit astronomical works written in Rājasthān and elsewhere in northern India in the eighteenth century seem *not* to have been influenced by Jayasiṃha. In fact, it seems probable that Khayr Allāh Khān was the sole designer of this ambitious project, though Jayasiṃha supported it enthusiastically and contributed to it financially if not to any great extent intellectually; the *Zīj-i Muḥammad Shāhī* was never even translated into Sanskrit as had been the *Almagest*. And the translation of the *Almagest*, though extant in some two dozen complete or fragmentary copies, does not seem to have been used at all by those who composed treatises on astronomy in Sanskrit in the late eighteenth and nineteenth centuries.

Hunter, however, claims to have met at Ujjayinī the grandson of one of Jayasiṃha's assistants whom he believed to be capable of carrying on the tradition because, while trained in traditional Indian astronomy, he possessed manuscripts of the *Siddhāntasamrāṭ* and of a Sanskrit translation of Napier's logarithms, and he acknowledged the superiority of European science. To Hunter's regret, this paṇḍita soon died, "and with him the genius of Jayasiṃha became extinct".[89]

86. *Siddhāntasamrāṭ*, vol. 2, pp. 1162-1165.

87. Storey, pp. 93-95.

88. W. Hunter, "Some Account of the Astronomical Labours of Jayasinha, Rajah of Ambere, or Jayanagar", *AR* 5 (1797), 177-211, esp. 205-209.

89. *Ibid.*, 210.

and then gives Sanskrit equivalents or explanations of them. In doing this the translator demonstrates his knowledge of the traditional Sanskrit terminology in geometry and in astronomy. From time to time either he, or more probably the person who computed the longitude of the solar apogee in 1765, adds Indian material; thus the *Sūryasiddhānta* is wrongly mentioned as using 22/7 as a value of π,[79] and the Indian measurements *aṅgula* and *yava* are added to the usual Persian *farsang*, *mīl*, and *gaz*.[80] But otherwise this is a straightforward translation of an introductory manual of astronomy through which a Sanskrit reader could learn the elements of late Islamic astronomy, but nothing about its methodology.

The most conscientious effort, however, to make Islamic astronomy and its methodology available in Sanskrit was that of Savāī Jayasiṃha of Jayapura in the early eighteenth century. Unfortunately, I have not yet had access to the unique manuscript, in the Mahārāja's Museum at Jayapura (no. 46), of Nayanasukhopādhyāya's translation of Naṣīr al-Dīn's *Tadhkira* with the commentary of al-Barjandī;[81] it would indeed be fascinating to examine it and to discover in what form the "improvements" to the Ptolemaic planetary models devised in Marāgha were transmitted to eighteenth century India. But Jagannātha's translation of Naṣīr al-Dīn's version of the *Almagest*, the *Siddhāntasamrāṭ*, has been published, though not critically edited; from this it is apparent that Jagannātha also had access, presumably through the earlier Sanskrit translations used by Munīśvara, Kamalākara, and Nityānanda, to at least some of the views of Ulugh Beg and of his colleague, Jāmshīd al-Kāshī.[82] For, after the thirteenth and last book of the *Almagest*, he adds a supplement which includes a *yantrādhyāya*, in which he describes the instruments that Jayasiṃha had set up in his observatories in imitation of those installed by Ulugh Beg at Samarqand,[83] and an explanation of Ulugh Beg's and al-Kāshī's derivations of sines.[84] And this is followed by a series of notes on how to deal with traditional aspects of Indian astronomy that are not directly touched on by Ptolemy or that are treated in a different manner by Ptolemy but not, in Jagannātha's opinion, fully enough. He even tacks on at the end a description of the *Sūryasiddhānta's* planetary theory, presented in the traditional style.[85] The ambiguity towards scientific method implied by the inclusion of this material in Jagannātha's work is characteristic of Jayasiṃha's approach to astronomy.

79. *Hayatagrantha*, p. 16.
80. *Hayatagrantha*. p. 137.
81. *CESS* A4.
82. Storey, pp. 72-73.
83. *Siddhāntasamrāṭ*, vol. 2, pp. 1031-1048.
84. *Siddhāntasamrāṭ*, vol. 2, pp. 1048-1085.
85. *Siddhāntasamrāṭ*, vol. 2, pp. 1165 sqq.

and it computes the longitude of the sun's apogee "at the present time" for A. H. 1178, which began on 1 July 1764.[72] These conclusions are rendered doubtful, however, by the fact that both the references to Kāshī and the computation of A. H. 1178 are omitted by Nāgeśa, and are therefore likely to be interpolations in the other two manuscripts. This doubt is strengthened to a certainty by the existence of a manuscript of the *Hayatagrantha* copied by Ṭīkārāma Jyotiṣī in 1730 in the Mahārāja's Museum in Jayapura (no. 24), and the recording in 1875 of another in Oudh that was copied in 1694.

The *Hayatagrantha*, therefore, was probably written in the seventeenth century, but on the basis of a Persian work different from that available to Nityānanda in 1639. For the *Hayatagrantha's* parameters for its planetary models, which are completely Islamic, differ from those of Romaka as presented in the *Siddhāntarāja*. The *Hayatagrantha* refers by name to ʿAlaʾ al-Dīn ʿAlī al-Qūshjī (*allāma kauśaji nāma ulūkavegasya guruputra*) for his determination by "our observation" (*asmadrasada*) of the obliquity of the ecliptic,[73] and for the use of sunset epoch in Arabia (*arabadeśa*);[74] and it mentions "our observation" *(asmābhir vedhena rasadaḥ)* of the longitude of the solar apogee in Muḥarram 841 A. H., which is July 1437.[75] This suggests that the Persian original of the *Hayatagrantha* is the *Risālah dar hay'at* or *Fārsī hay'at* composed by al-Qūshjī[76] at Istanbul and dedicated to the Ottoman Sulṭān Muḥammad ibn Murād (1451-1481), the conqueror of Byzantium; the work was known in Mughal India as the commentary by Muṣliḥ al-Dīn Muḥammad al-Anṣārī and was dedicated to the Emperor Humāyūn (1530-1556). The arrangement of the two texts supports this hypothesis; each contains an introductory section in two parts, two main sections (divided into six and eleven *bābs* respectively in Persian, into four and ten in Sanskrit), and a supplement. I have not been able as yet to examine a copy of the Persian original in order to test this hypothesis. But the fact that the section on chronology in the *Hayatagrantha*[77] is a revision of that in Ulugh Beg's *Zīj*[78] confirms the suggestion that the former represents a product of the school of Samarqand.

I do not wish now to go into the details of the *Hayatagrantha*. It should suffice to state that it consistently transliterates the Persian technical terms,

72. *Hayatagrantha*, p. 69.
73. *Hayatagrantha*, p. 24.
74. *Hayatagrantha*, p. 128.
75. *Hayatagrantha*, p. 69.
76. Storey, pp. 75-77.
77. *Hayatagrantha*, pp. 128-133.
78. L. P. E. A. Sédillot *Prolégomènes des tables astronomiques d'Oloug-beg* (Paris, 1853), pp. 7-28.

al-Rūmī) of computing the sine of 1° and even of 1′.[67]

Unfortunately, the Wellcome Institute's manuscript breaks off in the midst of Nityānanda's descriptions of the Islamic planetary models so that I do not know the extent to which the rest of his work is indebted to Muslim astronomy. But a sufficient portion of the *Siddhāntarāja* has been investigated to show that his planetary system is completely Islamic, though some of its elements are reworked to fit into a traditional Indian mode of expression. But, despite some assertions (not uncommon in classical Sanskrit texts on astronomy) that the Romaka computations lead to results closer to observed positions than do the Sūryasiddhānta's or Brahmagupta's, Nityānanda shows no understanding of the role of observations in improving the models of celestial motions devised by astronomers or their parameters. He has, in fact, done nothing but to recast a Sanskrit translation of an Islamic astronomical work into a form more congenial, and perhaps more acceptable, to an orthodox *jyotiḥśāstrin*.

Indeed, we have already seen that such a Sanskrit translation of a work dependent on Ulugh Beg's *Zīj* was available in the seventeenth century, in Benares as well as in Delhi. And a manuscript of a Sanskrit *Jīca Ulugbegi (Zīj-i Ulugh Beg)* is preserved in the Mahārāja's Museum is Jayapur no. 45; it was acquired from Surata through Nandarāma Josī, who is probably the Nandarāma Miśra who wrote voluminously on astronomy and astrology at Kāmyakavana in Rājasthān between 1763 and 1778.[68] We do not yet know whether this translation is identical with that used by Munīsvara, Kamalākara, and Nityānanda. But that it was expected that translations of astronomical works would be made from Persian into Sanskrit (as they were under the Moghuls also from Sanskrit into Persian) is indicated by the existence of a special Persian-Sanskrit dictionary of astronomical terms intended to facilitate the process. This is the as yet unpublished *Pārasīprakāsa* composed under the patronage of Shāh Jahān in 1643 by Mālajit,[69] a scholar from Srīsthala in Gujarat who was awarded the title of *Vedāngarāya* by the Emperor for his efforts.

One such translation that illustrates again the influence of the Samarqand school on Indian astronomers is the *Hayatagrantha*.[70] This was edited a decade ago on the basis of three manuscripts in Benares, of which the oldest was copied by Nāgesa in 1765. The editor believed that it was composed in Benares in the eighteenth century; for it refers to Kāshī several times,[71]

67. *Siddhāntarāja* 3, 19-85.
68. *CESS* A3, 128b-130b.
69. *CESS* A4.
70. Ed. V. Bhaṭṭācārya as *SBG* 96, Vārāṇasī 1967.
71. *Hayatagrantha*, pp. 22, 95, 101-102, and 120-121.

In fact, Nityānanda further feels constrained to cast his expression of the mean motion parameters of the planetary theories of his Muslim source in the traditional Indian form, and to give instructions for deriving from mean longitudes computed according to the Romaka those computed according to the Saurapakṣa and the Brāhmapakṣa, presumably to demonstrate that differences already exist within the Indian tradition, and that therefore the unfamiliarity of the Islamic parameters is not to be regarded as in itself vitiating them. Thus the normal Indian divisions of the Kalpa and other units of time are described;[59] the mean motions of the planets, their nodes, and the zodiac (*i.e.*, precession) are given as integer numbers of revolutions in a Kalpa;[60] and the computation of the *ahargana* follows the traditional pattern, though the epoch is noon at Laṅkā, which is (mean) sunrise at Romaka.[61] The mean longitudes resulting from following these rules are then corrected by *bījas*, whose purpose seems to be to compensate for the inaccuracies involved in expressing the Islamic mean motions as integer rotations in a fixed time; Nityānanda states that they are necessary to bring the results into conformity with observations.[62]

The dimensions of the Romaka's planetary models, however, are presented in Ptolemaic terms as eccentricities and radii of epicycles; and the circumferences of the *manda* and *śīghra* epicycles of the Saura and Brāhma pakṣas are reduced by Nityānanda to the same terms.[63] The models themselves are thoroughly Islamic, with equants, protective spheres, and crank-mechanisms for the moon and Mercury.[64] The cosmology is almost equally Islamic;[65] the earth is surrounded by spheres of the Indian water, fire, wind, and space rather than the Aristotelian water, air, and fire, but beyond that come the seven planetary spheres in proper order. The eighth sphere, that of the zodiac, rotates at a precessional rate of 1° in 70 years; and the ninth sphere, crystalline and containing the constellations, rotates daily. Here there is no apology offered, nor indeed any justification of the presentation of these alien theories in Sanskrit.

Nityānanda's sine table, however, which gives the sine to five sexagesimal places for every degree from 1° to 90° with R equalling 60, is fully justified mathematically; for he gives complete rules for its computation, including Jāmshīd al-Kāshī's method (which was repeated by Qāḍī Zādah

59. *Siddhāntarāja* 2, 2-21.
60. *Siddhāntarāja* 2, 22-27.
61. *Siddhāntarāja* 2, 28-34.
62. *Siddhāntarāja* 2, 35-37.
63. *Siddhāntarāja* 3, 3-18.
64. *Siddhāntarāja* 3, 197 sqq.
65. *Siddhāntarāja* 3, 180-196.
66. WHMRL V. 36 ff. 18v-19.

"Having examined the *Romakasiddhānta* [*i.e*, a *zij al-Rūmi*], the *Saura*, and that of Brahmagupta, and knowing the (longitudes of the) planets corrected separately (by each), I have composed an accurate siddhānta".

"It always attains in every way the equality between computation of the planets' (positions) and observation that comes from the Romaka. In this (science, however,) they know that the *Sauratantra* is like a Veda, and that even that composed by Brahmagupta possesses suitable methods".

"Then who was (this) Romaka who is numbered among the *munis*, the gods, and so on? I will tell you the answer to this (question); listen, as it was agreed to previously by Sūrya and Aruṇa":

"because of (their) fondness for history and stories. Even Bhāskara was known as Romaka because of a curse pronounced by Indra: Yavana lived in Romaka's city."

"When the curse was removed because of the favor of these two, the sun himself in ancient times composed the best treatise here, which has the form of tradition *(śruti)* though in the guise of being Romaka's".

Nityānanda has based this myth, as he himself indicates, on one in the *Jñānabhāskara* or *Sūryāruṇasamvāda*[55] wherein Sūrya claims that he revealed the *Romaka(siddhānta)* to Romaka when he was born among the Yavanas because of a curse of Brahma, and that the *Romaka* was then revised by Romaka in Romakanagara. The author of the *Jñānabhāskara* was, I believe, thinking of the astrological *Romakasiddhānta* which claims to be part of a *Sriṣavāyanasamhitā*,[56] whereas Nityānanda refers to a work on Islamic astronomy. It is tempting, because of the name, to think of one of the works composed by Qāḍī Zādah al-Rūmī,[57] the teacher of and collaborator with Ulugh Beg perhaps his commentary on al-Jaghmīnī's *Mulakhkhaṣ fi al-hay'a*. Whatever the case may be, Nityānanda feels it necessary to justify Islamic astronomy to his audience not on the basis of a rational discussion of its methodology and an observational testing of its results (though he does state its superiority without adducing any evidence), but on the pretext of its being derived from the revelation of an Indian deity. Such a camouflage is certainly not new, as students of Abū Maᶜshar's *Kitāb al-ulūf*, for instance, well know;[58] but it is significant that even the most enlightened Indian astronomer of the seventeenth century did not dare to base his claims on the evidence of the senses.

55. A. Weber, *Verzeichnis der Sanskrit-Handschriften* (Berlin, 1853), p. 287.
56. *CESS* A5.
57. Storey, p. 67.
58. D. Pingree, *The Thousands of Abū Maᶜshar* (London, 1968).

Beg's *Zj*, for that zīj seems not to describe the eccentric-epicyclic planetary models with the protective spheres *(pāli)* of Ibn al-Haytham and the later Islamic astronomers though Kamalākara does;[49] Kamalākara, however, does not mention the equant.

Moreover, Kamalākara speaks with approval of the computation of planetary distances by the Yavanas on the basis of the internesting of the solid *(mūrta)* spheres[50] – a computation that differs from the normal Indian procedure of making the distances of the planetary spheres inversely proportionate to the numbers of their rotations in a Kalpa.

It is not surprising, then, to find him quietly presenting as perfectly possible the Ptolemaic view of precession that Munīsvara had so heatedly attacked.[51] Nor is it uncharacteristic that his fifth *adhikāra* is a treatise on geometric optics, a subject never before, to my knowledge, discussed in such detail in Sanskrit. I presume that here also he has utilized an Islamic source, though I have not as yet been able to identify it.

Kamalākara, then, was quite willing to prefer a Muslim opinion even though it is contrary to that of the *ṛṣis*. But he neither accepted the methodology of Islamic astronomy, nor abandoned the basic procedures, models, and parameters of Indian astronomy. Two decades before he wrote, however, another Indian astronomer had gone much further in accommodating Islamic science.

Nityānanda[52] was a Gauda Brāhmana connected with the court of Shāh Jahān at Delhi. In 1628 he completed an enormous *Siddhāntasindhu*, which he dedicated to Shāh Jahān's minister Āsaf Khān; no manuscripts of this work are available to me. In 1639 he composed a smaller work, entitled *Siddhāntarāja*, in twelve chapters. Of this I have examined a fragment in the Wellcome Institute Library in London (V. 36). This manuscript of 39 folios (numbered 1-36 and 38-40) contains the first two and a large part of the third chapters of the work.

In the *Siddhāntarāja* Nityānanda boasts that he will present absolutely new (that is, Islamic) material, whereas his predecessors have merely repeated each other[53] – not an unjustified criticism of Indian astronomers. But he feels it necessary to disarm his critics in the following verses,[54] which I translate thus:

49. *Siddhāntatattvaviveka* 2, 255-284.
50. *Siddhāntatattvaviveka* 2, 497-500.
51. *Siddhāntatattvaviveka* 2, 470.
52. *CESS* A3, 173a-174a, and A4.
53. *Siddhāntarāja* 1, 9.
54. *Siddhāntarāja* 1, 14-18.

a particular fixed star. Thus he severely criticizes the Pārasīkas, their Yavana predecessors, and their Indian followers, for their arrogance in adhering to a doctrine dependent on their own deductions *(svamati)* even though they are contrary to the opinions of the *ṛṣis*;[41] at one point he even asserts that ridicule arises against anyone who has confidence in the words of the Yavanas on this matter through misunderstanding the true meaning of precession in Indian astronomy and trusting those observations that the Yavanas call *rasada* (Arabic *raṣad*).[42] Munīsvara's objections to precession were attacked by Kamalākara's brother, Raṅganātha,[43] in his *Lohagolakhaṇḍana*, which in turn was assailed by Munīśvara's cousin, Gadādhara,[44] in a work entitled *Lohagolasamarthana*.

Thus Munīśvara's knowledge of the Sanskrit version of an Islamic astronomical work has not been allowed to influence his astronomical theories in any significant way. At best he refers with indifference to some aspect of Islamic science, but more commonly he feels at least obliged to deny validity to what he does find it necessary to mention. And his ultimate weapon against the observational basis of Ptolemaic astronomy is ridicule of what does not conform to the sayings of the ancient sages.

A more tolerant view of Islamic astronomy is manifested by Kamalākara in the *Siddhāntatattvaviveka* that he completed in 1658, as by his brother Raṅganātha in his *Bhaiṅgīvibhaṅgīkaraṇa*.[45] Kamalākara agrees with the Yavana opinion that the inhabited parts of the earth rise above the sphere of water so as, however slightly, to alter the local horizon, though he hastens to add that this opinion does not contradict the gods and *ṛṣis*.[46] Like Munīsvara he refers to Khāladātta, which he wrongly locates 22° West of Romaka; but he proceeds to give a set of the terrestrial coordinates – he calls longitude *tūla* (Arabic *ṭūl*) – of twenty cities.[47] The only cities on this list that are located outside of India are Kabul and Samarqand; and in the seven cases where cities are included in Ulugh Beg's geographical lists, the coordinates, with the exception of a few misreadings of *abjad* numbers, are identical.

Kamalākara confirms his acquaintance with Ulugh Beg by referring to the computation of a table of sines by "Mirjolukabega".[48] This knowledge probably reached him, however, through a more elaborate treatise than Ulugh

41. *Siddhāntasārvabhauma* 1, 38-39;1, 123;2, 253-254; and 2, 274-275.
42. *Siddhāntasārvabhauma* 2, 279.
43. *CESS* A5.
44. *CESS* A2, 115a.
45. *Bhaṅgīvibhaṅgīkaraṇa*, pp. 31-32.
46. *Siddhāntatattvaviveka* 1, 120-126.
47. *Siddhāntatattvaviveka* a, 172-174; Essay Table VIII 27.
48. *Siddhāntatattvaviveka* 2, 89.

section of the *Siddhāntaśiromaṇi*.[34] In this he criticizes the theory of the Yavanas (i.e., the Muslims) that there is an unmoved crystalline (*kāca*) sphere supporting the sphere of the constellations (*mūrtimat*) and enabling it to rotate daily from East to West; for, he says, the crystal could not bear such a weight, especially since the sphere of the constellations in its turn bears the weight of the sphere of the zodiac. What else he might have derived from a Muslim source I do not know, as I have not had an opportunity to examine manuscripts of his other works.

The same is also true of most of the *Siddhāntasārvabhauma*, which was completed by Munīśvara[35] on 7 September 1646; of its twelve adhyāyas, on which Munīśvara wrote his own *ṭīkā*, only the first two and part of the third have been published with their commentary. In these chapters are found such relatively trivial matters as the recording of the definition of a sidereal month according to the Pārasīkas[36] (Munīsvara claims that the concept is useful for astral omens, but not in astronomy); it is stated that the origin of longitudes in the geographical tables of the Pārasīkas is a city called Khāladātta near Romaka[37] (in fact, of course, this place is the Eternal Islands – *al-jazā'ir al-khālidāt* – of Arabic geographers); it is claimed that, even though the methods of the Pārasīkas for correcting the mean longitudes of the planets beginning with the moon are described in the language of the gods (that is, in Sanskrit), yet they must be rejected by the wise because they are without proof;[38] and it is mentioned that, whereas for the orthodox the blue sky is a sphere of metal (a *lohagola*), the Pārasīkas claim that the heavenly spheres are crystalline.[39] All of these matters, even the last, seem to trouble Munīśvara very little; the reader is warned against some, but never in a very emphatic manner. He was much more incensed by the theory of precession when understood to imply a tropical rather than a sidereal reference system. For the Indians, though they have various theories of precession and trepidation,[40] traditionally used them only for the correction of the sun's declination; the juncture of the sun's declination circle with the equator may be permitted to move with respect to the fixed stars, but the traditional Indian method of describing mean motions as integer numbers of sidereal rotations within a *Kalpa* or a *Mahāyuga* necessitated, in Munīśvara's opinion, the unswerving connection of the origin of the zodiac with

34. *Marīci* 1, 2, 1-6.
35. *CESS* A4.
36. *Siddhāntasārvabhauma* 1, 17.
37. *Siddhāntasārvabhaumaṭīkā* 1, 136.
38. *Siddhāntasārvabhauma* 2, 222.
39. *Siddhāntasārvabhauma* 2, 228.
40. D. Pingree, "Precession and Trepidation in Indian Astronomy before A. D. 1200", *Journal for the History of Astronomy*, 3 (1972), 27-35.

are repeated often in Islamic zījes. These Goal-year periods, with the exception that Venus' eight-year period was altered to a 227-year period, were soon used as the basis of an enormous set of planetary tables, the *Jagadbhūṣaṇa*, compiled by Haridatta[27] in Mewar in Rājasthān in 1638; Haridatta, however, apparently used an Indian rather than a Persian set of astronomical tables in carrying out the computations of his own tables; the same is true of Trivikrama,[28] who composed a similar set of planetary tables based on the Goal-year periods at Nalinapura in 1704. Their knowledge of the Goal-year periods, then, simply provided a convenient framework for a form of perpetual tables, as it had in the West for al-Zarqālī and his source and successors.

In Benares in the eighteenth century the most important astronomers belonged to two Mahārāṣṭrian Brāhmaṇa families which had migrated to the city in the sixteenth century. The descendents of Cintāmaṇi, a member of the Devarātragotra residing at Dadhigrāma on the Payoṣṇī, include Munīśvara Viśvarūpa,[29] who was born in 1603, the year in which his father, Raṅganātha,[30] completed his famous ṭīkā on the *Sūryasiddhānta*, the *Gūḍhārthaprakāśikā*. Munīśvara's great rival was Kamalākara,[31] who was descended through Divākara, a pupil of Gaṇeśa, from Rāma of the Bhāradvājagotra, a resident of Golagrāma on the Godāvarī, not more than a few days' journey from Dadhigrāma. These two men and their numerous siblings, cousins, and nephews were all engaged in astronomical activities, but always within the context of the traditional Indian siddhāntas, particularly those of the Saura and Brāhma pakṣas. From time to time, however, they display an awareness of Islamic astronomy, which seems to have been available to them in the form of a Sanskrit translation of the *Zīj* completed by Ulugh Beg[32] at Samarqand in about 1437/1438 or some derivative of that zīj. The precise source of their knowledge remains obscure, however, we will return to the question of the Sanskrit versions of Ulugh Beg's astronomy later in this paper.

The earliest of these Benares astronomers to demonstrate a knowledge of Islamic astronomy is Kamalākara's father, Nṛsiṃha,[33] who wrote a commentary on the *Sūryasiddhānta* in 1611 and one on the *Siddhāntaśiromaṇi* of Bhāskara in 1621. Unfortunately, of these two gigantic works all that has been published is his commentary on the first adhikāra of the grahagaṇita

27. *CESS* A6.
28. *CESS* A3, 92b-93b, and A4.
29. *CESS* A4.
30. *CESS* A5.
31. *CESS* A2, 21a-23a; A3, 18a; and A4.
32. *CESS* A4; Storey, pp. 67-72.
33. *CESS* A3, 204a-206a.

of the astrolabe stars – Mahendra is quite willing to substitute Islamic procedures and values for the Indian, without any apparent effort to determine in what sense they might be superior; it was easier to take them over than to recast them in an Indian mold. In the other elements of astronomy he gives no indication that it is at all advisable to abandon or modify existing Indian theories.

The next major infusion of Islamic astronomy into science in Sanskrit seems to have occurred under the Moghuls, who, like Fīrūz Shāh, promoted intellectual exchanges between their Muslim and Hindu subjects. I employ the word "major" because there is one minor case of transmission that cannot be ignored. The Kerala astronomer, Acyuta Piṣāraṭī,[19] in his *Sphuṭanirṇaya* and *Rāśigolasphuṭānīti* written in the 1590's, proposed a formula for reducing the mean longitude of the moon in its orbit to an ecliptic longitude. Such a reduction had first been suggested, by Yaḥyā ibn Abī Manṣūr in the *Zīj al-mumtaḥan*, composed under al-Ma'mūn in the 820's. Acyuta probably bears witness to some transmission of at least a part of Islamic lunar theory that took place on the Malabar Coast in the fifteenth or sixteenth century.

A survey of Sanskrit astronomical texts composed in Western and Northern India in the sixteenth century, however, has yielded no reflexions of Islamic astronomy. I have examined, among others, the works, published and unpublished, composed by Jñānarāja[20] at Pārthapura on the Godāvarī in 1503; by Gaṇeśa[21] at Nandigrama in Gujarat between 1520 and 1552; by Dinakara[22] at Bārejya in Gujarat between 1578 and 1583; by Gaṇeśa's nephew and pupil, Nṛsiṃha,[23] at Nandigrāma between 1588 and 1603; and by Rāmacandra[24] at Benares between 1590 and 1600. Members of the families of several of these sixteenth century astronomers, however, were the leading advocates and critics of Islamic astronomy in Benares in the seventeenth century.

But the first author to whom we must refer is Visrāma from Jambūsara in Gujarat, who wrote a description of various astronomical instruments, the *Yantraśiromaṇi*,[25] in 1615. What is of immediate interest to us in his work is the inclusion of the Babylonian Goal-year periods of the planets,[26] which, of course, figure prominently in Book IX of Ptolemy's *Almagest*, and

19. *CESS* A1, 36b-38b, and A4. *Rāśigolasphuṭānīti* 47; *Essay* IX 2.
20. *CESS* A3, 75a-76b.
21. *CESS* A2, 94a-106b; A3, 27b-28a; and A4.
22. *CESS* A3, 102b-104b, and A4.
23. *CESS* A3, 202b-204a.
24. *CESS* A5.
25. *CESS* A5.
26. *Yantraśiromaṇi* 92-94.

is probable that he derived this second component also from an Islamic source. It was also known to his contemporary, Bhojarāja,[13] who wrote the *Rājamṛgāṅka*, with epoch of 21 February 1042, at Dhārā in Mālava.

It is highly unlikely, however, that this source should have been the translations of Euclid's *Elements* and of Ptolemy's *Almagest* that al-Bīrūnī claimed, in about 1030, to be engaged in.[14] This claim must be regarded as sheer bravado, since the knowledge of astronomers' Sanskrit displayed by al-Bīrūnī and his paṇḍitas was totally inadequate to the task. Another channel of scholarly exchange must be imagined, and of a more limited character; the only elements of Islamic astronomy that appear in Sanskrit texts at this early date relate to the sun and the moon.

The next phase in the transmission of Islamic astronomy to India, if we regard Bhāskara's[15] innovations in trigonometry as entirely his own, was the introduction of the astrolabe into Western India under the Tughluqs. Mahendra Sūri[16] composed the first description of this instrument in Sanskrit, the *Yantrarāja*, at Bhṛgupura – that is, modern Broach in Gujarat – in about 1370; according to his pupil, Malayendu,[17] who wrote a commentary on the *Yantrarāja* in about 1382, Mahendra undertook to write his treatise at the request of the astronomers of Fīrūz Shāh (1351-1388), during whose reign Sanskrit works were also translated into Persian. The astrolabe itself, of course, was developed in the Roman empire, though our earliest extant examples are Arabic. Mahendra and Malayendu not only introduced the construction and use of the instrument to Indian astronomers, but also an Islamic sine table in which *R* equals 3600 or 1, 0, 0; a table of declinations with the Islamic value, 23;35°, for the obliquity of the ecliptic; a list of the latitudes of 77 cities, most of which are in India though many are located elsewhere in the Middle East (the Ptolemaic system of representing terrestrial coordinates had not previously been used in Sanskrit texts); a catalogue of 32 astrolabe stars whose coordinates are derived from the *Almagest*, with the Ptolemaic longitudes corrected for precession (at the rate of 1° in 66 2/3 years) for 1370; and the cotangent tables normal on the backs of Eastern Islamic astrolabes.[18] Thus, in those elements necessary for the use of the astrolabe – trigonometry, terrestrial latitudes, and the coordinates

13. *CESS* A4. *Rājamṛgāṅka* 1, 25; *Essay* V 124.

14. D. Pingree, "Al-Bīrūnī's Knowledge of Sanskrit Astronomical Texts", in *The Scholar and the Saint* (New York, 1975), pp. 67-81.

15. *CESS* A4. *Siddhāntaśiromaṇi* 1, 2, 23; *Essay* Table V 43, and jyotpatti 16 and 21; *Essay* V 127-128.

16. *CESS* A4.

17. *CESS* A4.

18. *Yantrarājaṭīkā* 1, 5-6; *Yantrarāja* 1, 22-40, and 1, 70; *Essay* Tables XI 1 - XI 3.

between the sun and the moon. The result of Ptolemy's model, with its specified dimensions, is that the maximum equation at syzygies is 5;1°, at quadratures 7;40°. In the tenth century a model producing an identical effect first appears in India. The epoch of Muñjāla's[7] lost *Bṛhanmānasa* is 9 March 932 at noon (noon-epoch in itself is characteristic of Ptolemaic and Islamic astronomy, but alien to India); his extant *Laghumānasa* was commented on by Praśastadhara[8] in Kāśmīra in 958; and both of these treatises were encountered by al-Bīrūnī in the Pañjāb in the 1020's. It is likely, therefore, that, although Muñjāla's *Laghumānasa* is now found only in South India, he originally composed it in the West or Northwest, and had contact there directly or indirectly, with Muslim astronomers.

Muñjāla, however, following the Indian tradition, did not regard planetary models as cinematic or as in any way representing physical reality, but as calculating devices. Thus he felt free to replace Ptolemy's crank mechanism with an elegant formulation of the evection.[9]

$$0 = (\bar{v}_m - 11^\circ) \cdot \text{Cos}(\lambda_s - \lambda_a) \cdot \text{Sin}(\lambda_m - \lambda_s),$$

where λ denotes celestial longitude, and the subscripts m, s, and a denote moon, sun, and apogee respectively. Because of his choice to express his parameters as integer parts of a radius of 488, his simple lunar model generates a maximum equation of 5;2°; while his formula for evection, since he employs the integer 11° in the first factor, results in a maximum of about 2;29°, so that Muñjāla's maximum lunar equation at quadratures is 7;31° instead of Ptolemy's 7;40°.

A result closer to Ptolemy's was provided by Śrīpati,[10] who wrote various works between 1039 and 1056, at Rohiṇīkhaṇḍa, about 150 miles south of Ujjayinī. Śrīpati accepts the Brāhmapakṣa's simple lunar model with an epicycle that pulsates in a complex fashion as the body approaches the horizon, but which at its mean, in the meridian, produces a maximum equation of 5;2,7°. For the evection Śrīpati[11] accepts Muñjāla's formulation, but modifies the first term so that the maximum correction is 2;40° – just 1 minute more than Ptolemy's – and the maximum equation at quadratures, when the center of the moon's epicycle is on the meridian, is 7;42,7°.

Śrīpati also gives a complete formulation of the equation of time including both that part which is due to the sun's velocity, which had already been known to Brahmagupta,[12] and that dependent on the sun's longitude. It

7. *CESS* A4.
8. *CESS* A4.
9. *Laghumānasa* 18-19; *Essay* IX 1.
10. *CESS* A6.
11. *Siddhāntaśekhara* 11, 2-4; *Essay* V 123.
12. *CESS* A4. *Brāhmasphuṭasiddhānta* 2, 29; *Essay* V 66.

of planetary motion to scientists of the early ᶜAbbasid period,[2] emphasized – perphaps over-emphasized – the role of observation in refining planetary theories, and because of this emphasis developed both the necessary instruments and theories of optics and of the behavior of light. The most noteworthy Indian reaction to these aspects of Islamic astronomy, though characteristically having no discernible practical effect, was the program for the reform of Indian astronomy instituted by Jayasiṃha, the Mahārāja of Amber from 1700 till 1743.[3] Under his patronage were built the massive observatories at Vārāṇasī, Ujjayinī, Mathurā, Dillī, and his own Jayapura, while under his patronage the industrious Jagannātha[4] translated Euclid's *Elements* and Ptolemy's *Almagest* into Sanskrit, and the less well-known Nayanasukhopādhyāya,[5] at the dictation in Persian of Muḥammad Ābida (who acted as an intermediary in the way that Spanish-speaking Jews had for some of the Latin translators of Spain in the twelfth and thirteenth centuries) translated Theodosius' *Spherics* and Naṣīr al-Dīn's *Tadhkira* with al-Barjandī's *Sharḥ* thereon. But these achievements, impressive though they might appear, were at the end rather than the beginning of the Islamic influence on Indian astronomy. Let us turn now to the predecessors of that beginning.

Non-Ptolemaic forms of Greek astronomy, sharing many characteristics with what we can reasonably reconstruct of the theories of Hipparchus, were transmitted to India in the third or fourth century A.D., including several alternative planetary models and mathematical descriptions of other celestial phenomena;[6] these were given their characteristic Indian expressions in the fifth, sixth, and seventh centuries, from which developed four of the five schools of astronomy or pakṣas – in chronological order the Brāhma, the Ārya, the Ārdharātrika, and the Saura. These astronomical schools were generally conservative, but did permit the development of new computational techniques; and it is in the mathematics ancillary to astronomy – trigonometry and indeterminate equations – rather than in astronomy itself that the Indians excelled. There was no tradition of systematic observation in early Indian astronomy.

The Hellenistic lunar model that was transmitted to India allowed for only one inequality in its motion, which was accounted for by an epicycle; Ptolemy's model had a more complex structure, with the center of the moon's deferent traveling on a concentric at double the rate of the mean elongation

2. D. Pingree, "The Greek Influence on Early Islamic Mathematical Astronomy", *Journal of the American Oriental Society*, 93 (1973), 32-43.

3. *CESS* A3, 63a-64b, and A4.

4. *CESS* A3, 56a-58a, and A4.

5. *CESS* A3, 132a, and A4.

6. D. Pingree, "The Recovery of Early Greek Astronomy from India", *Journal for the History of Astronomy*, 7 (1976), 109-123.

Islamic Astronomy in Sanskrit

DAVID PINGREE*

The problem that I wish to examine in this paper involves in particular the awareness of and reaction to Islamic astronomy on the part of the traditional Indian astronomers practicing their science in northern India under the Moghuls. But in more general terms I believe that it illustrates the characteristic methods by which Indians throughout their history, until the nineteenth century, have responded to a superior foreign science (the judgment of superiority is here based on experience rather than on theory), though in the last phases of Moghul astronomy in Sanskrit one can perceive the beginnings of a new attitude foreshadowing that which has become the prevalent one among contemporary Indian scientists. Briefly, the shift in attitudes to which I allude is from the classical position that alien scientific systems may be adopted to Indian use, but that they must somehow be made to conform to the older Sanskritic tradition, and the resulting mutation ought to be presented as the revelation of a divinity or of an *ṛṣi*; the attitude of the contemporary Indian scientist is, normally, that there is one scientific method, internationally approved of and validated by experience and by its pragmatic success, and that the views expressed by gods and seers in the past are not guides to scientific truth, though some weaker souls may wish to vindicate them by reinterpreting them to conform to, and thus to anticipate, contemporary scientific hypotheses.

In the seventeenth and eighteenth centuries Indian intellectuals were forced to respond to a forerunner of modern science in the form of Ptolemaic astronomy as practiced by Muslims.[1] Though accepting Aristotelian physics, Muslim astronomers for a variety of reasons, not the least of which was the availability of the conflicting Ptolemaic and Indian models and parameters

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1. For biographical and bibliographical information on the authors discussed in these pages I refer the reader to D. Pingree, *Census of the Exact Sciences in Sanskrit* (henceforth *CESS*), of which Series A, vols. 1-3 have appeared as *Memoirs of the American Philosophical Society*, vols. 81, 86, and 111 (vol. 4 is in press), and to C. A. Storey, *Persian Literature*, vol. 2, part 1 (henceforth Storey), (London, 1958). See also D. Pingree, "Essay on the History of Indian Astronomy". (henceforth *Essay*, cited according to formulas and tables) in *Dictionary of Scientific Biography*. vol. 15, (New York, 1978), where the few technical matters touched on in this paper are discussed, and B. Datta, "Introduction of Arabic and Persian Mathematics into Sanskrit Literature", *PBMS* 14 (1932), 7-21.

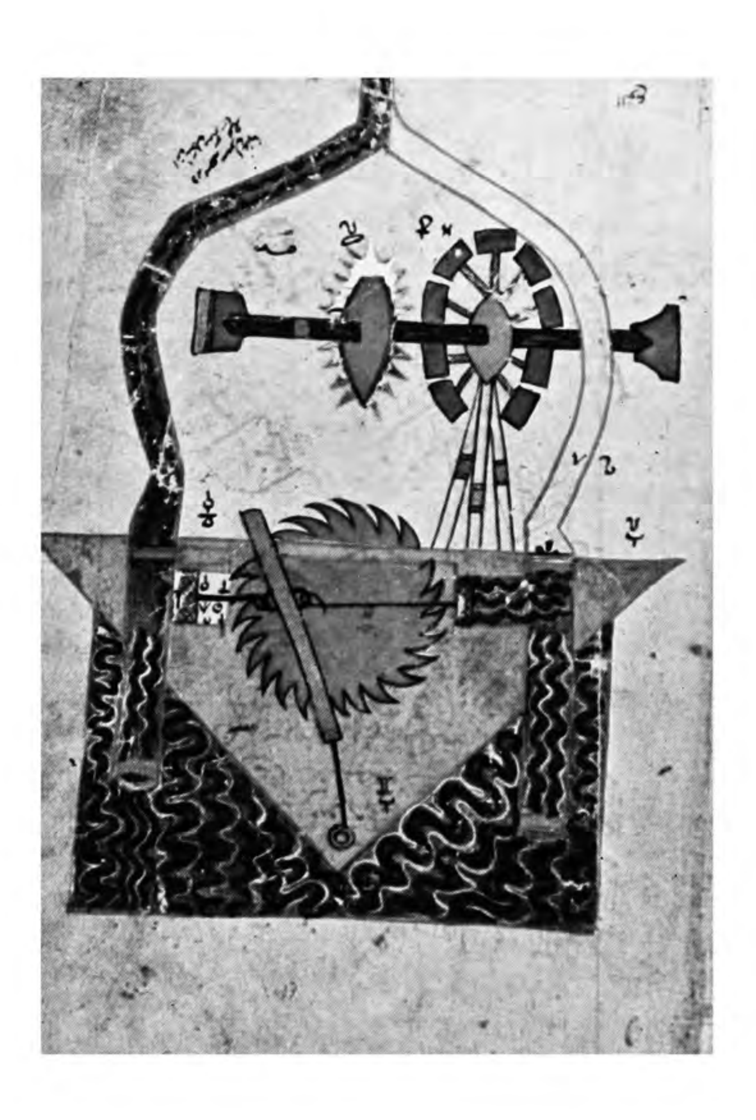


Fig. 7.

The main illustration of the complete machine: it is probable that this is a plan view, rather than an elevation (see Hassan op. cit. 56-59).

الى طرف البربخ فان ردادة ح ترتفع وينطبق ردادة د والهوا يجذب الماء من
انبوب ف فيمتلى بربخ ا ماء ومتى دفع قضيب ه انطبقت ردادة
ح وانبعث الماء ورفع ردادة د وصعد الماء بقوة فى انبوب ر
الدقيق الى فوق نحو عشرين ذراعا وهو مسافة طول الانبوب ثم
نتخذ بربخ آخر بهذه الصفة المتقدمة وما يتعلق به وعلى البربخ
ط وانبوب عليه ك وفيه ردادة عليها ى ويقابله من فوق
انبوب غليظ ثم دقيق وفيه ردادة عليها ص والقضيب وطرفه
حلقه وعلى الطرف الاخر قرصان بينهما قب وعليه ن وعند
تجويز ذلك يخرق فى ارض الصندوق من جهة ح خرق
وينزل فيه انبوب ب من بربخ ا الى حد نصفه ويوثق حاله
ويجعل بربخ ا على جالات ثابتات ويوثق ويخرج انبوب ر من اعلى
الصندوق معوجا الى جهة وسطه ويتخذ على وسط جانب خرق سهم
ق عند نقطة ه رزة قد اجيزت فى حلقة طرف قضيب ه وكذلك
يركب البربخ الآخر فى زاوية س من الصندوق ويتخذ عند وسط
جانب خرق السهم رزة قد اجيزت فى حلقة طرف قضيب ل وقد
تبين انه متى تحرك سهم ق يسارا اندفع الماء من بربخ ط فى انبوب ف
وارتفع من انبوب ب ما الى بربخ ا ومتى عاد السهم يمينا اندفع الماء
من بربخ ا فى انبوب ر وارتفع فى انبوب ك ما الى بربخ [illegible]

Fig. 6.

A drawing of one of the two cylinders — the ring at the end of the connecting rod is attached to the side of the slot-rod.

من المحور فى ارض الصندوق يدور على سكرجة وتحت القرص
حلقة يدور فيها المحور وعلى داير القرص دندانجات بارزات
عن الصندوق وعلى القرص في داخل الصندوق و وعلى
الدندانجات وهي خارجة عن جانب الصندوق س وعلى وجه
القرص وتد منتصب عند حرفه ثم تتخذ سهم واحد في احد طرفيه
ثقب فيه مسمار ثابت عند زاوية ع من الصندوق والطرف الاخر
مخروق طولا خرقا طوله
قطر دايرة يوترها راس
وتد القرص وهو في
الخرق ليصير الوتد في
غاية بعد عن زاوية ح
من الصندوق في طرف
الخرق وعلى وسط الخرق
ثم لال وعلى وسط
الخرق بيناه فاذن سهم
ق لا ميل له الى الجهة ح
ولا الى الجهة س وهو
بالحقيقة متوسط بينهما



ومتى دار قرص و من جهة ح الى الجهة س ربع دورة فان وتد
القرص الى ناحية س ويميل معه سهم ق وهو غاية ميله هناك
وحركة قرص و دايمة حتى يدور ربع دورة ويصير الوتد الى الجهة

Figs. 5, 6, and 7
(V.5, Figs. 139, 140, 141)

These illustrations are of the second of the alternative designs of the well-known slot-rod pump.

Fig. 5.

The two meshing cogwheels, the upper one driven from a paddle-wheel, the lower one having the slot-rod on its face. The orientation of this sketch is the same as in Topkapi 3472, whereas in Oxford Graves 27 it is turned through 90 degrees. The orientation shown here is almost certainly correct. The cogwheels are shown disengaged, otherwise the illustration is good.

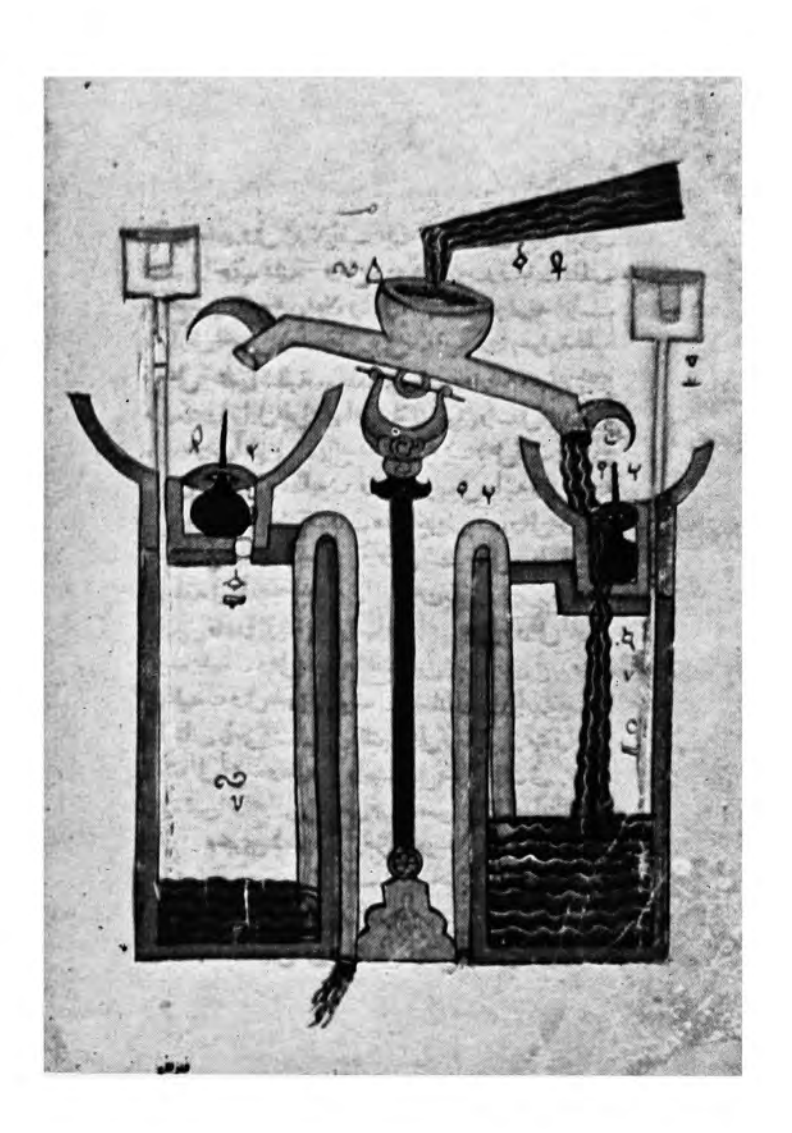


Fig. 4.

(IV. 10, Main illustration, Fig. 133).

Musical automaton. The whistles are at either side, at the top; air-pipes lead into them from the two tanks. The water runs into one side from the balanced supply pipe, causing the whistle to sound, until the float in the chamber at the top of the tank rises. The vertical rod on top of the float causes the supply pipe to tilt and discharge into the other tank. A siphon evacuates the first tank. The cycle repeats itself as long as water flows into the system.



الى فوارة ح فيفور منها صولجانا وكذلك ما دام الماء يجرى من
انبوب د وذلك ما اردت ايضاحه جليا واقول ان لهذا
الشكل وجه ثانى وممكن فيه ان يفور احد الفوارتين خيمة
وقضيبا واحدا ويفور الفوارة الاخرى صولجة ستة ثم يتبدلان
دايما وامثل ذلك صورة
واحدة يقوم مقام الاخرى
وذلك ان انبوب ه يجرى
فيه الماء من حوض ص ه
الى الكرة م ويفور منها في
انابيب ستة كقطع قسى
ينفذن في الدرقة وعليهن د و في داخل
انبوب الكرة انبوب ح فيه الماء من
حوض س ويفور من راسه بقوة
ويتلقاه مقعر الدرقة فينزل من
دايرها خيمة وفي وسط هذا الانبوب
انبوب آ يجرى فيه الماء من حوض س ه
ويرتفع حتى ينفذ في مركز الدرقة فيفور
قضيبا وهذا الشكل خارج عن الخمسين
شكلا وذلك ما اردت ايضاحه جليا
واصف ما صنعته وهو فوارة تتبدل في كل نصف ساعة مستوية

الشكل الخامس من النوع الرابع

Fig. 3.
(Addendum to IV.4, Fig. 125)

A fountainhead having three possible shapes. It is supplied from two tanks, with a switching system similar to that described for Fig.4 below. Three concentric pipes enter the fountainhead, the two inner ones from one tank, the outer one from the other. Water from the innermost pipe emerges as a straight jet; it emerges from the second pipe as a 'tent' - the water impinges on a convex plate and descends as a curved sheet. After change-over it emerges from the outermost pipe as a number of curved jets.

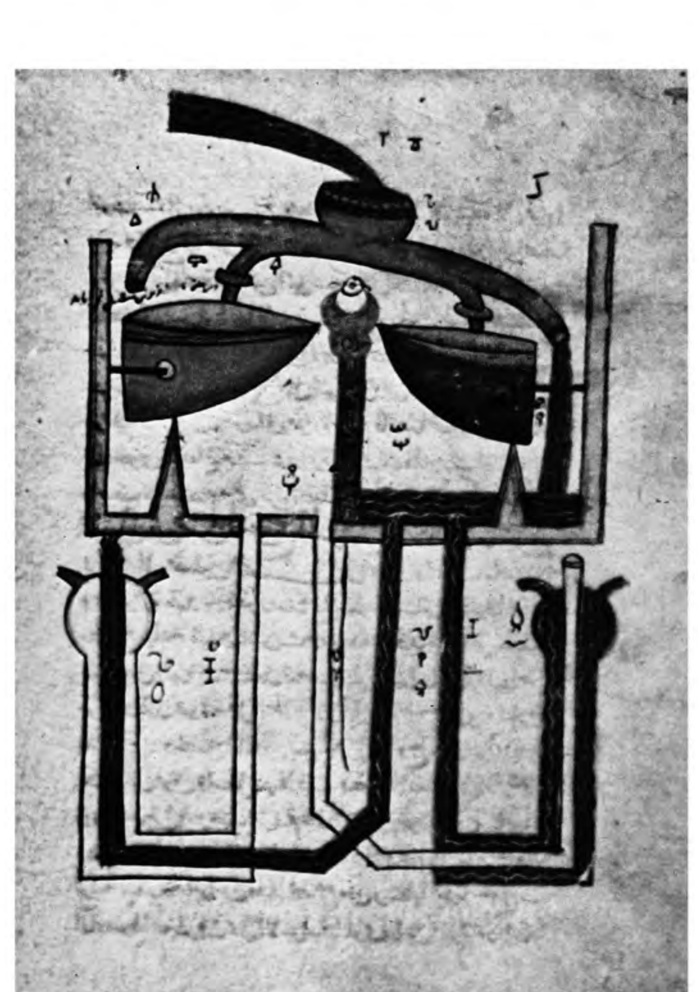
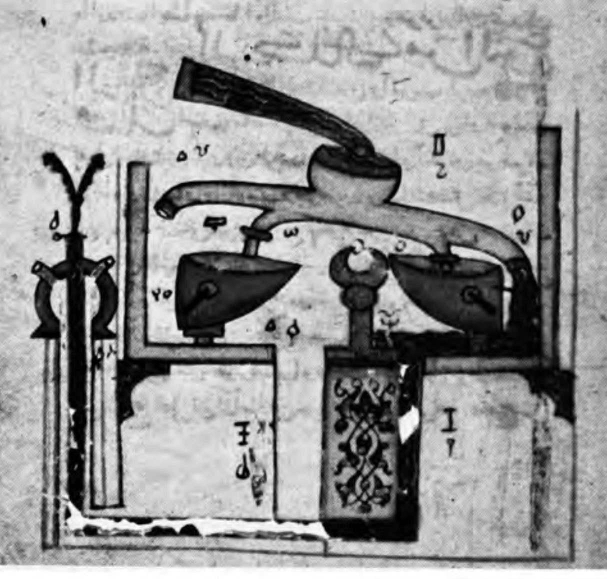


Fig. 2.

(IV.2, Main illustration, Fig. 122)

This is a doubled version of IV.1. One fountain-head emits a single jet when the other is discharging several. When they change over, the situation is reversed. Again, the rods attached to the tipping-buckets are omitted.

في عدة مواضع ولكن عظم كل كفة ما تسع من الماء خمسة ارطال بالبغدادي
ويوضع كل كفة تحت انبوب من الانبوبين الصغيرين اللذين عليهما
ق ف وضعا مستقيما وكفة عليها ط يصب اليها انبوب م ومتى امتلأت بماء
معلوم تخرج من جرعة في طرف انبوب م في ساعة مستوية فانها تميل
وتفرغ ما فيها من الماء الى الحوض ح ويرفع مؤخرها بشظية متصلة بها انبوب ب
فيميل الانبوب الكبير ويصب الى الحوض ع والى كفة تحت انبوب ق وعليها ا
يصب اليها فاذا امتلأت بماء معلوم تخرج من جرعة في انبوب ق ثم تفرغ ما فيها من الماء الى ال
حوض ع ويرفع مؤخرها بشظية متصلة بها انبوب ج فيعود الماء ينصب الى
حوض ح والى كفة ط وكذلك ما دام الماء يجري في ساقية الاصل وهذه صورته



Illustrations

(The numbers in parentheses give the Category, Chapter, and Figure Nos. from Hill)

Fig. 1.

(IV. 1, Main illustration, Fig. 121)

A fountain made to alternate by bleeding water from the main supply pipe, which is free to oscillate about an axle, into one or other of the tipping-buckets. As shown here, the discharge is into the right-hand side. When the tipping-bucket fills, it tilts and a vertical rod soldered to its rear face pushes the supply pipe, causing it to tip towards the left . The vertical rods are not shown in this illustration but appear in the parallel illustration in Topkapi 3472.

The fountainhead emits a straight jet when supplied from the left-hand tank, and several curved jets when supplied from the right.

the end of Chapter 10 of Category IV. The first part describes a woodwind instrument having 'fingers' that are raised and lowered in succession over its holes by cams fixed to the axle of a water-wheel. There is no illustration for this instrument. The second part of the addendum describes the device shown in the illustration mentioned above. This is a rocker-arm consisting of two flume-beam swapes joined at right angles, and oscillating about an axle located at the joint. The oscillation is produced by the 'bleeding' of water through a narrow pipe from the main supply channel into whichever of the flumes is temporarily horizontal; when the scoop at the end of the flume fills, this side tilts and the other flume comes to the horizontal and its scoop begins to fill, and so on. Al-Jazarī says that this device was not only used for fountains and musical automata, but that it was incorporated in many different machines.

References

1. A. K. Coomaraswamy, *The Treatise of al-Jazarī on Automata*, Museum of Fine Arts, Boston, 1924.
2. A. Y., Hassan, *A Compendium of the Theory and Practice of the Mechanical Arts*. Arabic text of al-Jazarī's work, collated from three of the best manuscripts. (Aleppo, Institute for the History of Arabic Science, 1978).
3. *Idem*, 'The Arabic Text of al-Jazarī's "A Compendium of the Theory and Practice of the Mechanical Arts"'. *Journal for the History of Arabic Science*, Aleppo, Vol. 1, No. 1, 1977. 47-64 in English, 129-165 in Arabic.
4. Donald R. Hill, *The Book of Knowledge of Ingenious Mechanical Devices*. An annotated translation of al-Jazarī's work. (Dordrecht, Reidel, 1974).
5. Sotheby, *Spring Islamic Sales*; catalogue for sale on 3rd April, 1978, 122-127.
6. E. Wiedemann, and F. Hauser, 'Über die Uhren in Bereich der Islamischen Kultur', *Nova Acta Abh. der Kaiserl. Leop. Deutschen Akademie der Naturforscher* 100, Halle 1915, 1-168.

The colophon is on page 293, after the end of VI. 5. On page 294 the letters of the 'secret' alphabet are given with their equivalents from the normal Arabic alphabet; the few lines of explanatory text are in a different handwriting from the rest of the manuscript - it is a badly written *naskhī*. There are three illustrations on page 295. The largest of these is in the centre of the page and is the main illustration of II.1, i.e. Fig. 80. It is clearly by a different draughtsman than the one who drew the illustrations for the main part of the manuscript; it is badly drawn and would be almost useless for explanatory purposes. Lower down, to the right and left of the page are two small, crude sketches of devices similar to those described by the Banū Mūsā, indeed the one on the right can be identified as their Model 79. Above either sketch there are passages describing these two devices (there is no text relating to the al-Jazarī device). These descriptions are not in the words of the Banū Mūsā. The handwriting is different again, a somewhat better *naskhī* from that on page 294, but not as good as as that of the main manuscript. At the bottom of the page there is the start of a passage in Fārsī, which continues on page 296. This passage, in yet another *naskhī* hand, is part of a treatise on weighing; at the bottom of the page there is a drawing of a balance with five pans. The contents of page 294 appear in most of the al-Jazarī manuscripts, and this page was probably added to supply an obvious omission. Pages 295 and 296, however, are quite extraneous.

Summarising from the foregoing tabulation, the only absolutely complete chapters are: III,1. - pitcher for dispensing hot and cold water; III,2. - pitcher for dispensing water; III,4. - peacock for dispensing water; IV, 1 to 6. - fountains; IV, 9 and 10. - musical automata; V,1. - pump; VI,2. - protractor; VI,3. - combination locks. All the illustrations are included in these fourteen chapters with, of course, all the main illustrations. There are also another five main illustrations which appear in incomplete chapters, namely: I,9., Fig. 76 - monkey candle-clock; I, 10., Fig. 78 - candle-clock of the doors; IV, 7 and 8., Figs. 130 and 131 - musical automata; VI,5. Fig.173 - water-clock of the sailor. Half of the illustration of the door, VI, 1., Fig. 141, remains. This fine miniature was originally on one full folio, and it seems likely that the other demifolio is lost for good. Fourteen of the dispersed main illustrations were published as plates in Hill, *op. cit.*, so we now have a record in two documents of 33½ of the original 50 main illustrations.

There are three chapters on water-raising machines, namely V, 1, 2 and 4, for which the text is complete although there are no illustrations.

In Hill, p. 238, Plate XXXII shows a device for which there was no description in the manuscripts that were available to me when I made the translation. There is, however, an addendum, to the text in the manuscript under review and in Topkapi 3472; in both cases this addendum occurs at

Category	Chapter	Pages in new numbering	Original contents	Omissions	
				Illustrations	Text
IV	Intro-duction	212	Text only	None	All except last two lines
	1 to 10	212 to 245	10 Chapters Figs. 120 to 133, Pl. 32	This Category illustrations, part of the	is complete, with all the except for the following text: end of chapter 7, start of chapter 8
V	1	245 to 248	1 Section Fig. 134	134*	None
	2	248 to 250	1 Section Fig. 135	135*	None
	3	250, 251	2 Sections Fig. 136	136*	End of S.1, start of S.2
	4	251 to 253	1 Section Fig. 137	137*	None
	5	253 to 260	3 Sections Figs. 138 to 141*	None (This chapter	None is complete)
VI	1	261 to 264, 269 to 273	3 Sections Figs. 142 to 148	Half of 142*	Introduction, start of S.1 (section 2 is complete but is misnumbered as section 1)
	2	273 to 277	3 Sections Figs. 149 to 152	None (This chapter	None is complete)
	3	277 to 286	2 Sections Figs. 153 to 166	None (This chapter	None is complete)
	4	287 to 290	2 Sections Figs. 167 to 172	172*	End of S.2
	5	291 to 293	1 Section Fig. 173	None	Last paragraph

Category	Chapter	Pages in new numbering	Original contents	Omissions: Illustrations	Omissions: Text
III	1	170 to 175	2 Sections Figs. 103, 104*	None (Chapter	None is complete)
	2	175 to 183	2 Sections Figs. 105 to 108	None (Chapter	None is complete)
	3	183 to 188	2 Sections Figs. 109 to 111	111*	Middle of S.2
	4	188, 189, 265, 266	1 Section Fig. 112*	None (Chapter	None is complete)
	5	266, 267	2 Sections Fig. 113	113*	Most of the chapter
	6	267, 268, 190 to 193	2 Sections Figs. 114, 115	114, 115*	Last few lines of S.2
	7	194 to 196	2 Sections Fig. 116	116*	Start of S.1, middle of S.2
	8	196 to 201	2 Sections Fig. 117	117*	End of S.2
	9	202 to 207	4 Sections Fig. 118	118*	Start of S.1, end of S.4
	10	208 to 211	2 Sections Fig. 119	119*	Start of S.1, end of S.2

Category	Chapter	Pages in new numbering	Original contents	Omissions	
				Illustrations	Text
I	9	108 to 110	2 Section Fig. 76*	None	All S.1 except last two lines
	10	110 to 113, 130, 131	2 Sections Figs. 77, 78*	None	End of S.2
II	1	114 to 117	2 Sections Figs. 79, 80	80*	All S.1 except last three lines
	2	117, 118	1 Section Fig. 81	81*	Middle of Section
	3	119 to 129, 132 to 139	5 Sections Figs.82 to 86	82*	End of S.1
	4	139 to 145	3 Sections Fig. 87	87*	None
	5	146 to 155	3 Sections Figs. 88 to 93	88*	All S.1, start of S.2
	6	156 to 159	2 Sections Figs. 94 to 97	94*, 97	Start and end of S.2
	7	160 to 162	3 Sections Fig. 98	98*	All S.1, centre of S.3
	8	162, 163	2 Sections Fig. 99	99*	End of S.2
	9	164 to 167	2 Sections Fig. 100	100*	Title, end of S.2
	10	168 to 170	2 Sections Figs. 101, 102	102*	Start of S.1, middle of S.2

Category	Chapter	Pages in new numbering	Original contents	Omissions: Illustrations	Omissions: Text
Cover		1	–	–	–
Introduction		2 to 4	Same	–	–
I	1	4 to 10, 69, 70, 11 to 30	10 Sections, Figs. 1 to 33	4*, 6, 7, 8, 10, 11, 13, 14, 15, 16, 18, 19, 20, 22 to 25, 28 to 33	End of S.1, centre of S.2, start and end of S.3, first few words of S.4, most of S.6 - only the start remains, all S.7, start and end of S.8, start and end of S.9
	2	30 to 36	5 Sections Figs. 34 to 40	34*, 39, 40	Most of S.1 - only the start remains, first few words of S.2, last few lines of S.3, all S.4, most of S.5
	3	59, 60 37 to 45	6 Sections, Figs. 41 to 47	41*, 42	All S.1, all S.2
	4	45 to 68, 71 to 76	15 Sections Figs. 48 to 59	48*, 51, 52, 59	End of S.1, last few lines of S.5, all S.6, start of S.7, end of S.12, start of S.13, end of S.15
	5	77 to 82	3 Sections Figs. 60 to 62	60*, 62,	Start of S.1, middle of S.3
	6	82 to 95 (86 is a duplicate of 85)	6 Sections Figs. 63 to 70	63*, 66, 67	Most of S.1 - only start remains, most of S.3 - only start remains, and some lines at the end, all S.4
	7	98, 96, 97, 99 to 103	3 Sections Figs. 71 to 74	74*	Last part of S.3
	8	104 to 107	3 Sections Fig. 75	75*	Start of S.1, most of S.3 - only the start remains

715, or December 1315. This is therefore the third oldest known copy of al-Jazarī's work, being pre-dated by Topkapi Ahmet III 3472 and Topkapi H. 414. The list of Mss given by Hassan (*op. cit.* 60-62) brings up-to-date the the list in Hill 3-6. Of these fourteen Mss I have now examined the originals of eight, namely: Bodleian Library, Oxford, Graves 27 and Fraser 186; University of Leiden Or. 117 and Or. 656; Bibliothèque Nationale, Paris, Fonds Arabe 2477 and 5101, Suppl. Pers. 1145 and 1145a. I have also seen pages from Hagia Sophia 3606. I have photocopies of Topkapi Ahmet III 3472 and Chester Beatty Library, Dublin, No. 4187. I have yet to examine, therefore, Topkapi Hazine H 414 dated 672/1274, Topkapi Ahmet III 3350 dated 863/1459, and Topkapi Ahmet III 3461, date unknown. Hassan assesses the first of these three as a very good copy, the second as inferior with regard to the illustrations, and the third as uneven, with some sections poorly written and illustrated but most of it of good quality. Leaving aside the question of completeness, it seems that the 715/1315 manuscript can be ranked among the best. The calligraphy is excellent, the illustrations are very fine, and the text, though not without errors, is free from major blemishes.

The manuscript has Persian pagination, added at some time after the copy was made. Unfortunately, this pagination is unreliable: some pages are unnumbered, some are out of order, and in certain cases the lengths of the lacunae indicated by the gaps in the numeration do not match the lengths of the missing text. The expedient was therefore adopted of numbering the pages (i. e. demifolios), starting with the cover, and then sorting the pages so numbered into order. This produced the following sequence: 1 to 10, 69, 70, 11 to 36, 59, 60, 37 to 68, 71 to 95, 98, 96, 97, 99 to 113, 130, 131, 114 to 129, 132 to 189, 265 to 268, 190 to 264, 269 to 296.

In the following analysis this new pagination is used, and the illustrations are given the Figure Nos. from Hill. In the right-hand column the abbreviation 'S' is used for Section. Al-Jazarī provided one main illustration for each chapter and numbered them from 1 through to 50; these are marked with an asterisk.

Notice of an Important al-Jazarī Manuscript

Donald Hill *

This notice refers to a manuscript of al-Jazarī's book on machines entitled *The Book of Knowledge of Ingenious Mechanical Devices*, or *A Compendium on the Theory and Practice of the Mechanical Arts*. It had previously been thought that the manuscript of this work dated 715/1315 had been completely dispersed; see, for example, Hill *op. cit.* p. 5, and Aḥmad Y. al-Hassan in Vol. 1, No. 1 of this journal. Happily, this assumption proved to be incorrect, since about two thirds of the original manuscript, the property of the Hagop Kevorkian Fund, was included in Sotheby's Spring Islamic Sales on 3rd April 1978 in London. As reported in "The Times" of 4th April 1978, the manuscript was purchased by Messrs. Spink and Son of St. James's, London for a little over £160,000. I would at the outset like to express my sincere gratitude to these two highly respected and responsible companies for the courtesy and co-operation that they have extended to me in the furtherance of my researches. Sotheby's gave me access to the manuscript before it was sold, and sent me a number of colour transparencies of the illustrations. I had fruitful discussions with members of the staff of Spink and Son, who provided me with a complete black-and-white photocopy of the manuscript. I am also very grateful to both companies for having given me permission to publish this paper, and to include in it, as I saw fit, any of the material that they so generously provided.

Some time ago a number of the illustrations were removed from the manuscript and found their way into various public and private collections. In my book I published twenty-one of these illustrations, these being all that I was able to trace. There are, however, 66½ illustrations missing from the manuscript sold by Sotheby's, so clearly a number remain undiscovered. Most of the lacunae in the manuscript can be accounted for by the removal of these illustrations, since either the accompanying demifolios of text or the surrounding text were removed with the illustrations.

The manuscript is written on thick polished paper, 314 mm. by 219 mm. to the page, in very fine *naskhī* script with 21 lines to the page. The colophon on page 207a (Persian pagination – see below) gives the name of the scribe as Farkh ibn ᶜAbd al-Laṭīf and the date of his copy as the end of Ramaḍān

* 3 Amey Drive, Great Bookham, Surrey, England. I wish to express my gratitude to the Royal Society for awarding me a grant in 1978/79 to assist me in my work on medieval Arabic technology.

"Much has been said about the composition of (books on) the art of medicine, and the part of it which is on therapy is dealt with far more than is necessary, (while) the theoretical part (is dealt with) far less than is necessary".

It is possible that the concentration of theoretical matter and the dearth of description of practical procedures rendered it less useful and so less popular than al-Majūsī's book. And hence, it never diffused to the West like the other book. The same fate seems to have befallen another *kunnāsh* written within 50 years of *K. al-Mi'a* and contemporary with al-Majūsī's book, perhaps for the same reason. *Al-Muᶜālajāt al-buqrāṭiyya* is a large system of medicine in 10 *maqālāt* compiled by Abū'l-Ḥasan Aḥmad al-Ṭabari,[49] the court physician to Rukn al-Dawla (932-976). This book has a similar arrangement of subject matter to *K. al-Mi'a* and deals with all the classical topics of medical theory. Diseases are likewise set out in the usual head-to-toe arrangement. The book is heavily biased towards theoretical discussion and is of high intellectual calibre. Relatively little attention is paid to matters of practical importance and it could not have had much appeal for the average practitioner. The author explains in the introduction to the book[50] that he has compiled it in order to salvage medicine from the hands of the ignorant and the superficial, and to return it to the tradition of the ancients he so admires. The result is not unlike *K. al-Mi'a*, except that it is perhaps less lucid and complete. This book likewise did not claim the attention of the Latin translators, nor was its author apparently known in the Latin West. In recent times, its fourth *maqāla*, which is on ophthalmology, was studied by Hirschberg,[51] and some of its sections on diseases of the skin were translated into German by Mohammed Rihab.[52] Otherwise, it has remained relatively unknown.

Despite these considerations, the question with regard to al-Masīḥī's book must remain largely unanswered. It must be said in conclusion that the omission of this book from the mediaeval list of translations deprived the West of an important compendium, equally as valuable as al-Majūsī's *Kāmil al-ṣināᶜa* and of the same calibre as Ibn Sīnā's *Canon*.

49. Some meagre facts about al-Ṭabarī's life are to be found in IAU, I, 321. See also GAL I, 237; SI, 422.

50. There is a complete manuscript of this work in the Bodleian Library, Oxford, Marsh 158.

51. J. Hirschberg, *Geschichte der Augenheilkunde bei den Arabern* (Leipzig, 1908), pp. 107-114.

52. Mohammed Rihab, "Der arabische Arzt aṭ-Ṭabarī. Übersetzung einzelner Abschnitte aus seinen 'Hippokratischen Behandlungen'" *Sudhoffs Archiv*, 19 (1927), 123-168.

territories. If they translated only what was available to them in Spain, then the choice of book was indeed dependent on its being present there. This raises the further question of why *K. al-Mi'a* was not available in Spain. In fact, as was noted earlier none of al-Masīḥī's other books were translated into Latin either, nor does he himself seem to have been known to the Latin West. This is indeed a puzzle. Why, for instance, should ᶜAlī b. al-ᶜAbbās al-Majūsī's *kunnāsh*, *Kāmil al-ṣināᶜa* have been translated into Latin and not *K. al-Mi'a*?[48] These writers are quite comparable to each other: both were Persians and wrote their books in Persia within 50 years of each other. Thus, the problem of geographical diffusion should have been the same for both. The books are comparable in scope and style. Al-Majūsī's book is a large two-volume encyclopaedia on the whole of medicine, theory and practice. Like *K. al-Mi'a*, it discusses every aspect of medicine and classifies its subject-matter in the same thorough way. The accounts are of the same order of lucidity and precision. *Kāmil al-ṣināᶜa* is likewise written with great authority. However, there is a difference between the two in the amount of space given to practice as opposed to theory. In this sense. *Kāmil al-ṣināᶜa* is the more balanced, for half of it is on theory and half on practice, whereas, *K. al-Mi'a* is mainly devoted to theory, as has been shown above. This is in line with al-Masīḥī's pupose in writing the book, for he says in his introduction:

فاقتضى هذا العلم بحسب ما هو موجود عليه في نفسه اما في جملته فانه يرتب ويسهل ويلخص واما في الجزء النظري منه فانه يتمم ويصحح واما في العلاجات فانه يختصر ويقرب فقمت بهذه الشرائط كلها وبذات الوسع والطاقة فيها فخرج أصح وأتم وأسهل واصغر ما امكن .

"This science, by its present nature, requires that it should be arranged in its entirety, simplified, and summarised. As to its theoretical part, this should be made complete and corrected; and as to its therapeutic part, this should be condensed and made more accessible. So I fulfilled all these conditions to the utmost of my capacity, and (the book) emerged more correct, complete, and easy to use, and as short as possible."

And further on in the introduction, he adds this:

نقد اكثر الكلام في التصنيف وفي صناعة الطب والجزء العلاجي منه زائد على المقدار الواجب بافراط والجزء العملي قالل عن الواجب .

48. ᶜAlī b. al-ᶜAbbās al-Majūsī lived and worked during the reign of the Persian ruler, ᶜAḍud al-Dawla (949-982). Very little is known of his life (see IAU, I, 236; al-Qifṭī, *op. cit.*, p. 232; GAL, I, 237; SI, 423). His book. *Kāmil al-Ṣināᶜa*, also known as *al-Kitāb al-Malakī* (because it was dedicated to ᶜAḍud al-Dawla), was translated into Latin by Constantine the African as *Liber Pantegni* in the 11th century, and by Stephen of Antioch as *Liber Regius* in 1127, and enjoyed great fame and popularity in mediaeval Europe. (See Leclerc, *op. cit.*, II, 359 and H. Schipperges, *Die Assimilation der arabischen Medizin durch des lateinische Mittelalter*, *Sudhoffs Archiv*, Beihefte, Heft 3, Wiesbaden, 1964, p. 35).

hyenas, and tigers, as many other *kunnāshāt* did, nor does it mention poisonous substances or medicines, as was also usual.

Comment

It should be clear from the foregoing description of contents that *K. al-Mi'a* is a large, comprehensive work which attempts to systematise the whole of medical theory. The major part of the book is devoted to theoretical considerations, and only a small part deals with practical procedures. There are no quotations from other medical authorities, a practice common to many *kunnāshāt*, where a quotation from an Arabic or Greek physician was often added either to lend support to the writer's opinion or to provide additional information on the subject under discussion. There may have been other reasons also.[47] The general style of the book is authoritative and it may be that the author's sense of his own authority made the inclusion of the sayings of others unnecessary. Be that as it may, it is easy to see why such scholars as Leclerc and Sarton saw *K. al-Mi'a* as a model for Ibn Sīnā's *Canon*. Its encyclopaedic range, extreme systematisation, and authority are indeed reminiscent of the *Canon*.

In a sense, it may have even been preferable to the *Canon*. For, the scholarship of the Middle Ages which was so inclined to favour rigid classifications and compact systems might well have welcomed the relative brevity of *K. al-Mi'a*. Furthermore, al-Masīḥī's book is written in a lucid and didactic manner that would have made it of the greatest use to the mediaeval pedagogic tradition. It is extraordinary therefore to observe that al-Masīḥī's encyclopaedia was not known to the Latin West.

This of course raises the unresolved question of why certain Arabic works and not others were translated into Latin.From the point of view of subject matter and form, *K. al-Mi'a* should have been ideal for the Latin mediaevalists. Its omission from their translations is difficult to explain. Of course, it is known that the bulk of translation from Arabic into Latin was carried out in Spain, and therefore the choice of material for translation must have been dictated in part by the availability of books in Toledo and other Spanish centres of translation. We do not know what efforts were made by the Latin translators, if any, to obtain books from elsewhere in the Islamic

47. Such quotations have been of the greatest value to modern scholarship. For example, Ibn al-Jazzār's book, *Zād al-Musāfir*, provided Daremberg during the last century with important fragments of Rufus' medical writings which he incorportated into his *Oeuvres de Rufus d'Ephèse* (ed. C. Daremberg and E. Ruelle, Paris, 1879). ʿAlī b. Rabban al-Ṭabarī's *Firdaws al-ḥikma* (ed. by M. Z. Siddīqī, Berlin, 1928) contains a rich variety of quotations from Greek, Arabic, and Indian sources. Pseudo-Thābit's *K. al-Dhakhīra fī ʿilm al-ṭibb*, (ed. by G. Sobhy, Cairo, Government Press, 1928), also transmits many quotations from others.

on the uterus and on pregnancy. This is followed by a book "on the treatment of diseases special to men" and concerns inflamations and ulcers of the genital organs. But it also includes something on what may be termed "sexual medicine".[45] This is concerned with the ill effects of sexual over-indulgence and not with ways of increasing pleasure, as is to be found in the comparable sections of some other *kunnāshāt*.

The head-to-toe diseases end with gout and sciatica. The books after that are on external, or skin diseases. This includes the conditions affecting the hair such as alopecia and splitting of hair, and the disorders of the complexion like vitiligo, and the scars of smallpox and ulcers, as well as other skin diseases. Such a section on external diseases was a standard component of all *kunnāshāt*. It also included a certain amount on cosmetics: such matters as the dyeing and curling of hair, the removal of unwanted hair and remedies for purifying the complexion and changing its colour. The external disease part of *K. al-Mi'a*, however, has very little cosmetic emphasis and no directions for the dyeing or curling of hair. Book 99 is on fractures and dislocations. It is a short chapter and describes the general treatment of the body when a fracture takes place: this consists of evacuation and blood-letting in order to prevent the seepage of humours from the fracture site. There are some directions on how to correct dislocations and fractures and on binding the affected part.

But it is unlikely that such brief directions as are given would have been of much use to an orthopoedic practitioner. What is more likely is that, as this was a routine inclusion for most *kunnāshāt*, it was included here for the sake of completeness and does not necessarily imply that the author had ever practised any of the procedures he describes or that he intended them for practical purposes.

The last book is on another standard inclusion of *kunnāshāt*, namely, the bites of venomous animals: these include the snake, scorpion, tarantula, and wasp; there is also a chapter on the bites of rabid dogs, again a favourite subject with Arabic physicians. Snake and scorpion bites are treated, as might be expected, with the theriac, since theriacs were originally made up as antidotes, and it was only later that their use became widespread as universal panaceas.[46] The book does not deal with the bites of large animals, such as lions,

45. In Arabic literature, this phrase includes a number of related topics: the place of coitus in health; disorders associated with the performance of coitus such as impotence and priapism; gonorrhoea and nocturnal emission. The remedies in such sections often included numerous aphrodisiacs. Some books added chapters with a strongly erotic flavour on such subjects as ways of increasing sexual pleasure and sexual positions.

46. The theriacs were a group of compound medicines said to have been devised by the Greek physician, Andromachus, as antidotes against poisons of all types. By Galen's time, they were in use for other conditions as well, and later still, they became universal panaceas. See G. Watson, *Theriac and Mithridatum* (London, the Wellcome Historical Medical Library, 1966).

For example:

"Book 65: The treatment of diseases occurring in the organs of sensation and motion, that is to say the treatment of spasm, tetanus, flaccidity, numbness, and tremor".

"Book 79: the treatment of gastric evacuations, that is to say the treatment of cholera, dysentery, and lientery".

In general, the head-to-toe disease section of *K. al-Mi'a* is relatively short and relegated to a place of secondary importance. All chapters on disease are short and contain a cursory account of causes and symptoms. This is unlike the practice employed in many *kunnāshāt* of the time, where the head-to-toe diseases were given a place of pre-eminence as being the main subject matter around which the other principal subjects of medical theory were arranged. The reason for this departure in al-Masīḥī's book is evident from the fact that he devotes considerable space to the theoretical principles underlying the causes and mechanisms of disease, symptoms, and therapy. Hence, when he comes to the description of actual disease entities, he is very brief on their specific features, having already explained their general characteristics at length.

The account of epilepsy is a typical illustration:

(f. 282, 1.4 – 1.11)

قد يكون من آفة مخصوصة بالدماغ ويكون من مشاركة المعدة وبعض الاطراف كالرجل او اليد او مشاركة الرحم للنساء بأن يصعد من كل واحد من هذه الاعضاء ما يسد منافذ بطون الدماغ فيحدث الصرع فان كان يصعد من بعض الاطراف فينبغي في وقت النوبة قبل ظهورها أن يشد فوق ذلك الموضع برباط شدا محكما الى أن تنقطع النوبة ثم يطلى الموضع بالفلفل والخردل والفرفيون وعسل البلادر ويترك حتى ينتفط .

"(Epilepsy) may occur from a malady specific to the brain, or it may occur in association with the stomach and some of the extremities, such as the leg or the hand; or because of association with the womb in women. Thus, something ascends from each of these organs which obstructs the apertures of the ventricles of the brain and so epilepsy occurs. If it ascends from one of the extremities, it will be necessary at the time of the fit and before it happens to bind (the part) above that place with a firm, tight bandage until the fit is stopped. Then the part should be painted with pepper, castor, euphorbium, and anacardium honey, and left until it blisters".

It will be readily seen that there is no clinical description here. The rest of the chapter is concerned with therapy, which is given in some detail.

The list of diseases described goes down through the body in descending order. After the books on diseases of the urinary tract, there is a short section

significance, (this is to be differentiated from prognosis, which is the subject of book 54); the periods of disease, meaning the four stages of disease as classified by Greek and Arabic physicians: commencement, increase, culmination, and decline; and the three cornerstones of mediaeval disease theory: coction, crisis, and critical days. The subjects are dealt with in characteristically detailed and lucid manner, and the accounts are exactly in line with the earlier Greek teaching and with the other Arabic books on the same theme.

There are three books on the preservation of health. These include the healthful regimen to be adopted at various ages. Attention is to be paid to the diet, sleep, movement and rest, baths, massage, psychical events, and the ambient air – in other words, to the six non-naturals. This matter was a regular component of Arabic *kunnāshāt*, and was also treated as a separate subject, as the many Arabic tracts on hygiene testify.[44] Book 59 is on the principles of the treatment of diseases, and contains a clear statement of the physician's function with regard to disease and its management:

(f. 267a, 1.12 – 1.14)

فالطبيب فاعل كالمعين للطبيعة بأن يقرب منها الدواء وغيره من داخل أو خارج عل ما ينبغي في الوقت والمقدار فهو يحصر بحصولها ما تتقوى به فتستعين به في دفع المرض ولذلك صارت الطبيعة قد تدفع وتزيل كثيرا من الامراض من دون دواء أو طبيب وليس يقدر الدواء ولا الطبيب إزالة المرض البتة متى خارت القوة وعجزت

"The physician acts as an assistant to nature, in that he brings to it medicine and other things either internally or externally, in the correct amounts and at the correct times. For he aids (nature) to attain what strengthens it and assists it in repulsing the disease. In this way, nature repulses and eliminates many diseases without either medicine or physician, nor can either medicine or physician eliminate a disease once the strength has collapsed and become impotent".

Thus, here is a clear adherence to the Hippocratic attitude with regard to the importance of nature and to its standing as the real physician. There is then a detailed and highly systematic account of the things which have to be taken into account when deciding on the correct treatment. It is only at this point in the work that practical directions as to the management of specific diseases are given, but even then, there is little emphasis on therapeutic detail. The next series of books represent the head-to-toe disease section of the book. There is an unusual tendency to classify some diseases according to functional and pathological considerations rather than on the basis of pure anatomical site.

44. Qusṭā b. Lūqā, Isḥāq b. ʿImrān, Ibn Sīnā, Ibn al-Muṭrān, and many others wrote seperate tracts on hygiene.

The function of air is to be a cooling agent for the heart, which is conceived of as a furnace wherein the innate heat burns. The lung therefore acts as a bellows to cool the heart. Thus,

(f. 216b, 1.10 – 1.14)

فصارت الرئة تنبسط وتنقبض بانبساط الصدر وانقباضه ومتى انبسطت امتلأت تجاويفها هواء ومتى انقبضت اندفع الى خارج ما اندفع اليها من دخان القلب فالتنفس هو سبب حصول الهواء للقلب الذي به يتروح اولا وتبقى حرارته معتدلة نقية وتكون منه الروح الحيواني الذي بتوسطه تصل قوة الحياة والحرارة الغريزية الى جميع البدن

"The lung expands and contracts with the expansion and contraction of the chest. When it expands, its cavities fill with air, and when it contracts, the smoke of the heart which has been expelled to it is expelled to the exterior. For respiration is the means whereby the heart obtains the air with which it is fanned and (hence) its heat remains moderate and pure, and from which is created the animal spirit by whose agency the life force and the innate heat reach the rest of the body".

These ideas on respiration are very similar to the ideas expressed by Aristotle and Galen, in particular the concept of the bellows and the burning furnace wherein combustion takes place, and hence the need to expel 'the smoke of the heart'.[43] The next 9 books deal with 'pathology', for they concern the pulse, the urine, and faeces, and their features in health and disease.

The book on the pulse is complicated and detailed. Pulse lore was a most important aspect of the Arabic medical system. Arabic physicians routinely described 10 kinds of abnormal pulse. These went under certain names, such as the "mouse-tail pulse" and the "gazelle-like pulse", and their patterns were intricately described. This seems to have been a theoretical artifice more than anything else, and it is doubtful whether anyone actually ever felt most of what was described. Of no less importance was the subject of the urine. Al-Masīḥī goes into the matter of uroscopy at length and in great detail, with great emphasis on its pre-eminence in the art of medicine. He explains how urine is formed from the watery part of blood and stresses that its examination will give information about many internal conditions. The different kinds of pathological urine are described, which, like the kinds of pulse, were common to all Arabic medical writing.

The following books deal with several important subjects: on the anticipation of illnesses by warning signs, which was a review of signs of prognostic

43. There is a similar description in Aristotle's *De Respiratione*, transl. by W.S. Hett, Loeb Classical Library, (London, Heinemann, 1957), p. 479; and at greater length in Galen's *On the Usefulness of the Parts*, *op. cit.*, I, 316.

latter survives only in Arabic translation.[41]

The subsequent books have detailed discussions on the signs of psychical ailments, on secretions evacuated from the body, and on fevers. The book on fevers is devoted to the theoretical understanding of the nature and differentiation of fevers. He defines fever as a contranatural heat; the site of this heat in the body determines the type of fever it is, as follows:

(f. 194a, 1.15 – f. 194b, 1.2)

فمتى كانت في الارواح كانت حمى يوم وهي تنقضي اما في يوم واحد وإما في نوبة واحدة إن بقيت اكثر من يوم واحد ومتى كانت في الاخلاط كانت حمى العفونية وحمى العفونية منها دائمة وهي التي مادتها محصورة في العروق ومنها ذات افتراق ونوايب وهي التي مادتها خارجة عن العروق ومتى كانت في الاعضاء كانت حمى الدق .

"When the heat is in the spirit, it is an ephemeral fever; it goes either in one day or in one paroxysm. If it stays for longer than one day, and when (the heat) is in the humours, then it is a putrid fever. Putrid fever may be continuous, and that is when its matter is confined to the veins, or it may have periods and paroxysms, and that is when its matter is outside the vein. When (the heat) is in the organs, it is a hectic fever."

His account of fevers follows this pattern and makes the subject, which must have posed the physician of the time the greatest diagnostic difficulties, seem simple and straightforward. Book 41 is on the signs of diseases of various parts of the body. The next book gives an account of the signs of the temperaments. This describes the signs of a hot, cold, wet, dry temperament, and compounds of these (i. e. hot-dry, cold-wet, etc.), and how the temperament may be diagnosed from the colour, the facial expression, the touch, and the actions. The temperaments of organs are also included. There is a section on the indications from the facial features, the teeth, the nails, and the skin as to the temperament (for example, a hairy chest indicates a hot temperament of the heart). This science, (physiognomy, Arabic: *al-firāsa*), was a most important subject in Arabic medicine. Al-Rāzī has a large section on it in his *K. al-Manṣūrī*, and several Greek works on the subject were available in Arabic translation from the time of Ḥunayn b. Isḥāq.[42]

Book 44 is on respiration and forms a compact and interesting account of the physiology of respiration of the time. There is a reiteration of the doctrine of spirits and a discussion of their entry and elaboration in the body.

41. This tract has been translated from the Arabic by M. C. Lyons as *On the Cohesive Causes*, in *Corpus Medicorum Graecorum Supplementum Orientale, II*, (Berlin, Akademie-Verlag, 1969).

42. Notably, the book on physiognomy of the Greek sophist, Polemo, which survives only in Arabic translation as *K. Iflīmūn fī'l-firāsa*. The material here is very similar to that in *K. al-Mi'a*.

and urine are also listed here. Book 32 continues an account of drugs classified according to their qualities, degrees, and special effects; that is, under "heating medicines in the first degree", there follows a list of substances; under "those medicines which attract the humours", another list of substances, and so on.

Book 35 discusses the classification of diseases, their causes, and their signs. As if by way of introduction, al-Masīḥī explains something of the nature of all diseases:

(f. 164b, 1.15 – 1.20)

وإن الامراض واسبابها واعراضها كلها امور خارجة عن الطبع وغرض صناعة الطب هو ازالتها كلها على القصد الأول فان الذي يقصد إلى ازالته اولا هو المرض لأنه هو الذي يضر بالفعل إلا أنه لا يزول الا بزوال السبب الذي احدثه

"Diseases, their causes, and their symptoms are all contranatural matters. The purpose of the art of medicine is to remove them all, in order of priority. For (although) that which it is intended to remove first is the disease, because it is what is harmful in fact, (yet) it will not be removed unless the cause which has brought it about is removed (first)".

There then follows a classification of diseases according to the four primary qualities with examples to illustrate each type, and according to the compounds of the primary qualities, and whether these are accompanied by matter or not. As to the causes of disease, he classifies them and explains these in this way:

(f. 167b, 1.15 – f.168a. 1.1)

وأسباب الامراض ثلاثة اجناس احدها جنس الاسباب البادئة والثاني جنس الاسباب السابقة والثالث جنس الاسباب الواصلة والاسباب البادئة هي التي تؤثر في البدن وهي خارجة عنه مثل حرارة الشمس القوية التي تولد الحمى واما الاسباب التي تؤثر في البدن من داخل فما كان بينه وبين المرض سبب آخر فهو سبب سابق وما كان منها ليس بينه وبين المرض سبب آخر فهو سبب واصل .

"The causes of disease are of three kinds: the first is that of the immediate causes; the second is that of the antecedent causes; and the third, that of the connecting causes. The immediate causes are those which affect the body (but) are external to it, like the strong heat of the sun which gives rise to fever. As to the causes which affect the body from inside, if there is a connection between them and the disease, then it is an antecedent cause. But if there is no (causal) connection between the disease and one of them, then that is a connecting cause".

This classification is in fact very similar to the Galenic classification of the types of causes, as explained in his tract *De Causis Contentivis*. The

Books 30 to 34 are concerned with the faculties of medicines and their classification. The subject of medicines was of the utmost importance to mediaeval physicians. Here is a clear exposition of the theoretical approach to the use of medicines in terms of their qualities and their special actions, whether purgative, diuretic, emetic, and so forth. The author encourages the use of "empirical medicines", (*mujarrabāt*), but stresses that where possible, only one drug should be used at a time. These *mujarrabāt* are of some interest; many books were devoted to this subject during the Arabic period, including those by al-Kindī, al-Rāzī, Ibn Sīnā, Ibn Zuhr, Ibn al-Tilmīdh and many others. Sarton[37] was very impressed with the tradition of *mujarrabāt*, and held that it represented the earliest example of an experimental method in medicine. But in fact, the *mujarrabāt* were nothing to do with the experimental method but were rather medicines which had been found to work by experience.[38] Many of them had obvious magical associations, particularly in the later writings of the 14th century and onwards.

The book on simples classifies them in alphabetical order, using the earlier type of Arabic alphabet (which follows the Hebrew order). Under each medicinal herb, there is a definition of its properties according to degrees from 1 to 4. Thus, a medicine is described as 'cooling in the first degree' and 'drying in the fourth degree,'. Its special effects and properties, diuretic, purgative, binding, etc. are then listed. For example,

(f.135 b, 1.6 – 1.8)

افيون بارد في الرابعة يابس في الثانية ينفع من الاورام الحارة الملهبة خاصة من العين مجلب للسبات مخدر
للحس قليله ينفع في تسكين الاوجاع والتنويم وكثيره يقتل

"Opium is cold in the fourth (degree), dry in the second; efficacious in hot, inflamed swellings, especially of the eye; causative of lethargy; anaesthetic; a small amount of it is efficacious in stilling pain and for narcosis; a great deal of it kills."

This system of degree classification was a refinement of the Galenic arrangement whereby drugs were graded according to their qualities and their efficacy.[39] The Arabic physicians broadened and expanded Galen's ideas into a neat and well-ordered system.[40] Parts of animals are also included here as substances with medicinal properties, as for example with the livers of certain animals, which are used as sympathetic medicines in diseases of the liver. The gall, tongues, and secretions of animals, such as their saliva, milk,

37. Sarton, *op. cit.*, II, 94.

38. In this, one must agree with Ullmann who takes issue with Sarton in his special section on *mujarrabāt*, (*Die Medizin*, *op. cit.*, pp. 311-3).

39. For a study of the Galenic system of drug classification, see G. Harig, *Bestimmung der Intensität im medizinischen System Galens* (Berlin, 1974).

40. Al-Majūsī devotes a large section of his book (*op. cit.* above) to this classification of drugs.

al-Manṣūrī, is almost identical),[33] to the extent of repeating Galen's erroneous assertion that there were communications between the right and left ventricles. It was this assertion which was countered by Ibn al-Nafīs two hundred years later, and which earned him the enthusiastic description of "the discoverer of the pulmonary circulation" by certain modern writers.[34] The next book is also Galenic in concept, for it contains a teleological account of the function of organs on the lines of the large work of Galen, *On the Usefulness of the Parts of the Body*.[35] There is much useful information in this book on the physiology of the time, and a remarkably clear exposition of the role of the vital heat and the elaboration of the animal spirit.

The books that follow may be said to be about the environment: on airs and winds, on dwellings, and on waters. Books 12 to 18 inclusive are on dietetics: the principles governing the choice of food and drink which are connected with a study of the temperament, the season, and the preponderant humours; the faculties and qualities of simple foods; and the benefits and properties of wine and other drinks. Book 16 deals with the healthful preparation and cooking of food, and explains that foods are classified as digestible, indigestible, high in superfluities, or low in superfluities, and the like.

The next few books deal with the non-naturals. On the subject of evacuation, there is a lengthy book devoted to blood-letting ; its advantages and disadvantages, the indications for blood-letting, and how much blood to remove. It ends with a detailed and fascinating account of the technique of blood-letting, what instrument to use, what shape incision to make, whether along the length or width of the vein, and what to use to keep the vein patent. Al-Masīḥī's contemporary in Spain, Abū'l-Qāsim al-Zahrāwī, also left a long and detailed account of the technique of venesection and its indications.[36] Book 29 is on the signs of psychical origin, such as grief and anger. The observation is made here that anger leads to a yellow complexion, due to an increase in yellow bile. This brings to mind the use in this connection of the English word "choleric" and its obvious humoral origin.

33. For comparison, see Galen's description of the heart in his *On Anatomical Procedures*, transl. C. Singer, Wellcome Historical Museum Publications, (Oxford University Press, 1956), VII,175; 179-188. The anatomy of the heart is given in *maqāla I* of the *K. al-Manṣūrī*, "On the form and appearance of organs".

34. See M. Meyerhof, "Ibn al-Nafīs (XIIIth century) and His Theory of the Lesser Circulation" *Isis*, 23 (1935), 100-20.

35. Transl. by M. T. May, Cornell University Press, 1968.

36. *Albucasis on Surgical Instruments*, ed. and transl. by M. S. Spink and G. L. Lewis, (London, Wellcome Institute for the History of Medicine Publications, 1973), pp. 624-655 (on veins), and pp. 174-183 (on arteries).

This extract displays the general style of the book quite well. It also reveals the neat systematisation typical of Arabic writers. This economy of description of the faculties should be compared with the prolixity and disorganisation of Galen's work on the same theme, *On the Natural Faculties*.[31] The other books on the temperaments, the actions, and the spirits are just as well-ordered and provide a thorough review of the principles of medical theory in readily assimilatible form.

The two books on the like and unlike organs constitute the anatomy section of the work. These terms refer to the classification of the parts of the body into those whose constituents are homogenous, such as fat, bone, cartilage, and so on, and those which are made up of different tissues, such as arms, legs, hands, and so on. This division was common to Arabic anatomy, and derived from an Aristotelian classification of the organs of the body into 'homeomerous' and 'anhomeomerous' types.[32] The unlike organs are classified from top to bottom, in the same way as diseases, and in fact represent the internal organs. The anatomical descriptions are exact, as for instance this extract on the heart:

(f. 21b, 1.6 – 1.12)

والقلب صنوبري الشكل قاعدته الى جهة أعالي البدن ورأسه المخروط الى جهة أسافل البدن وقاعدة القلب موضوعة في وسط الصدر ومن جميع جهاتها ورأسه المخروط مائل إلى ناحية اليسار وللقلب غلاف من غشاء كثيف محيط به متميزا منه إلا عند قاعدته وفيه تجويفان أحدهما في الجانب الايمن والآخر في الجانب الأيسر وفي التجويف الأيمن الدم أكثر من الروح وفي الأيسر الروح أكثر من الدم ومن الايمن الى الايسر منافذ لطيفة .

"The heart is cone-shaped, its base being towards the top of the body, and its pointed end towards the lower part of the body. The base of the heart is in the middle of the chest (equally) on all its sides, (but) its pointed head is inclined towards the left side.

"The heart has an envelope made of a thick membrane, which surrounds it but is distinct from it (i. e. not adherent) except at its base. It has two cavities, one on the right side and one on the left. There is more blood than spirit in the right cavity, and more spirit than blood in the left. There are small apertures from the right to the left (cavity)".

This description is interesting in more ways than one. It is modelled on Galenic anatomy, like other Arabic books of the time, (for example, the section on the anatomy of the heart in al-Rāzī's famous *kunnāsh*, *K.*

31. Translated by A. J. Brock, Loeb Classical Library (London, Heinemann), 1928.

32. *Cf.* Aristotle, *De Partibus Animalium*, 646b, 11-20, in *The Works of Aristotle*, ed. and transl. by W.D. Ross (Oxford University Press, 1910-49). This section includes a discussion on the "homeomerous" and the "anhomeomerous" parts.

black humour go beyond the nature of blood, because they have reached the limits of combustion. The presence of all these in the body is normal, meaning that blood is the true nutrition that is intended and phlegm is a humour which could be digested so that the body could be nourished by it".

And still on the subject of humours, al-Masīḥī explains how it is that they cause disease:

(f. 30b, 1.12 – 1.15)

وهذه هي الاخلاط التي تسمى اركان البدن وأما إذا زادت على هذا المقدار أو الكيفية فخارجة عن الطبع لسبب مرضي ويجب ان تعدل إن كانت مفرطة الكيفيات وتستفرغ إن كانت كثيرة المقادير

"These are the humours which are called the fundamental components of the body. But if they increase over their (normal) amount or their qualities, they become contra-natural due to a pathological cause. It is (then) necessary to bring (the body) back to a state of moderation if (the humours) are in excess in their qualities, and to evacuate it if they are excessive in amount."

In this brief extract, he enunciates the principles of disease causation and therapy which were the essence of the humoral theory followed by himself, his contemporaries, and the Greek physicians before him. As to the other aspects of the humoral theory, the faculties are explained in a systematic manner:

(f. 36a, 1.14 – 1.22)

فالبدن اربع قوى احداها نفسانية وهي التي تفعل الاحساس والتمييز والتحريك بالاختيار والثانية حيوانية وهي تعطي جميع البدن الحياة والحرارة الغريزية والثالثة طبيعية وهي التي تعطي جميع البدن الغذاء وتدفع فضولاته والرابعة مولدة وهي التي تعد الزرع وتكمل الجنين وقد تعد في صناعة الطب القوة المولدة مع القوة الغاذية ويسمى جميع ذلك الطبيعية .

"The body has four faculties, the first is psychic and it is (the faculty) which effects sensation, discrimination, and voluntary motion. The second is animal and it is the one which gives life and the innate heat to the whole of the body. The third is natural, and it is the one which gives the whole of the body nutrition and which expels its superfluities. The fourth is generative, and it is the one which prepares for fertilisation and which completes the growth of the foetus. In medicine, the generative faculty is counted with the nutritive faculty, and the two together are called the natural (faculty)".

The first book is a highly theoretical and philosophical introduction to medicine. The second book presents a lengthy account of the theory of elements and how they enter into the formation of the human body:

(f. 6b, 1.17 – f. 7a, 1.12)

والاجسام الاول بالطبع اربعة النار والهواء والماء والارض وإنما سميت اجساما أول لانها لا تتركب ولا تتكون من اجسام أخر غيرها... والبدن مركب من الاعضاء المتشابهة الاجزاء وكل واحد من هذه قد يكون إما اولا في المني وإما من بعد ذلك في الدم والمني يتكون من الدم والدم من الغذاء والغذاء إما حيوان وإما نبات والحيوان حال بدنه كحال بدن الانسان فاذن كلها من النبات والنبات يتكون من الارض والماء فاذن بدن الانسان مركب من الاسطقسات الأول .

"The elements in nature are four: fire, air, water, and earth. They were named elements because they are not constructed or formed from any other bodies. . . and the (human) body is made up of organs of like parts. Every one of these (organs) exists either in the semen first or in the blood after that. And the semen is formed from blood, and blood (is formed) from food, and food is either animal or plant. The state of an animal's body is like that of man, so, therefore, all of them come from plants; and plants are formed from earth and water. Therefore, the body of man is made up of the primary elements".

He goes on to define the qualities of the four elements as hot, wet, dry, etc. His style is clear, didactic, and detailed. The other sections on medical theory are likewise lucid. The book on the humours, for example, could not have left any student of the art in much doubt as to the nature of the humours in health and disease:

(f. 28a, 1.1 – 1.11)

والاخلاط وهي اربعة الدم والخلط الأصفر والخلط الاسود والبلغم وحصولها كلها في البدن بسبب الغذاء بمعنى أن بعضها غذاء وهو الدم وبعضها فضولات الغذاء وهي الثلاثة الاخلاط الباقية لأن البلغم فضلة متقدمة على الدم لأن الغذاء لم ينهضم ولم ينضج فبقي على نيوءته والخلط الاصفر والخلط الاسود مجاوران لطبيعة الدم لأنهما قد صارا في حد الاحتراق ووجودها كلها في البدن طبيعي بمعنى أن الدم هو الغذاء الحقيقي المقصود والبلغم خلط يمكن أن ينهضم فيغتذي به البدن .

"The humours are four: blood, the yellow humour, the black humour, and phlegm. They are all to be found in the body by reason of food, meaning that some of them are food, and that is blood, and some are superfluities of food; these are the three remaining humours, for phlegm is a superfluity which comes before blood because the food has not been digested and has not reached coction yet, so that it stays unripe. The yellow humour and the

and external diseases. The external diseases section here is subdivided into diseases of the scalp, the skin, and the skin colour. Two other topics, which were also very commonly included in medical compendia, although not uniformly so, appear: fractures and dislocations, and venomous bites. Several books are devoted to the subject of medicines both, simple and compound, matter of the highest importance in any medical book.

Subjects of Books in K. al-Mi'a

Introduction to medicine
The elements
The homeomerous organs
The anhomeomerous organs
The usefulness of the parts of the body
The humours
The temperaments
The faculties
The actions
The spirits
The natural states of the body
Airs and winds
Dwellings and waters
Faculties and qualities of foods
Drinks and wines
Sleep and waking
Massage
Movement and rest
Baths
Purgation
Emesis
Venesection
Diuresis
Perspiration
Gargling
Clysters
The signs of psychical origin (grief, anger, etc..)
Faculties of medicines
Simples
Medicines with special properties
Causes and signs of disease
Psychical ailments
Secretions evacuated from the body
The types of fevers
Swellings
The signs of diseases of various parts of the body
Respiration
The pulse
The urine
The faeces
Premonitory signs
Periods of disease
Coction
Crisis
Critical days
Favourable and unfavourable signs
The signs of disease
The preservation of health
Principles of treatment of diseases
The treatment of fevers
The treatment of swellings
The treatment of ulcers
Diseases from head to toe
Pregnancy and diseases of the uterus
Diseases special to men
Diseases of the hair
Scars of ulcers
Disorders of skin colour
Diseases of the skin
Fractures and dislocations
Bites of venomous animals

are not properly organised, so that the divisions of the art are not known; there is either too much detail or too little; theory receives too little attention, while practical methods and therapy receive too much. For these reasons, the author has decided to write a book which will remedy all these failings in as synoptic a way as possible.

The result is an encyclopoedia of medicine in which everything is systematised as far as possible. It is organised on a basis of the standard divisions of medicine, (best expressed in Ḥunayn b. Isḥāq's pithy introduction to medicine, *al-Masā'il fi'l-ṭibb)*.[28] The descriptions are lucid, well-ordered, and there is indeed an attempt to make each book complete in itself. There is a strong emphasis on theoretical aspects, and indeed the major part of the book is devoted to theoretical principles and discussion. It is only when the 60th book is reached on f. 267b, that is, after two-thirds of the book have been gone through, that practical methods are included in any detail.

The index of "books" is set out soon after the introduction. Each section is named "the book of such-and-such." The subjects dealt with in these books have been listed on the following page. They do not correspond to the actual titles in *K. al-Mi'a*, where the same subject sometimes has several books devoted to it, but are meant here to convey a general idea to the reader of the contents of the *kunnāsh*. In this way, it may be seen that all the standard topics in medicine which were current at the time are covered: all essential aspects of the humoral theory, the naturals: which are the organs, the elements, the temperaments, the faculties, the actions, and the spirits; the non-naturals,[29] which are six and which may be picked out among the list of subjects early on in the *kunnāsh* as air, food and drink, sleep and waking, movement and rest, evacuations (detailed into purgation, emesis, venesection, and the like), and the passions of the soul (the signs of psychical origin); and the contra-naturals, meaning the cause and process of disease. There is a section on 'pathology', that is, coction, crisis, the pulse, and the urine; a section on prognosis; and a section on the preservation of health. All these were standard subjects of importance which were included as a matter of routine in most *kunnāshāt*. Likewise, there is the inevitable classification of diseases from head to toe,[30] and the other two classical subjects: fevers

28. This work, alternatively known as the *Isagoge*, was celebrated throughout the Middle Ages. It is setout in a question-and-answer form and summarises the medical theory of the time using a rigid classification of subject matter which became standard for all medical books thereafter. (This important work is still unedited and exists only in manuscript form.)

29. There are several studies on the non-naturals. For example, P. H. Neibyl, "The non-naturals", *Bull. Hist. Med.*, 45 (1971), 486-92; and L. J. Rather, "The six things non-natural, a note on the origins and fate of a doctrine and a phrase", *Clio Medica*, 3 (1968), 337-47.

30. This was a classification that was universally employed in Arabic medical textbooks and in the Greek medical books of late antiquity.

well written, and provided a wide selection of treatments.[21] It was recommended for use by students in the medical teaching syllabus of the *Chahār Maqāla*, as was noted above. Modern commentators have also been impressed with this book: both Leclerc and Sarton believed it to have been a model for Ibn Sīnā's *Canon*.[22] The book survives in at least 29 manuscript copies. The earliest of these is said to be to be dated 400/1010, which, if true, means that it must have been made either during the author's lifetime or shortly after his death.[23] There are six other early manuscripts, that is, dating from before 1300 A.D.[24] In the centuries that follow, there are manuscripts dating from each century, and a high concentration of very late manuscripts: five are said to be dated between 1233/1818 and 1300/1883.[25] Thus, manuscripts survive from every century beginning virtually from the date of death of the author until the end of the last century. This, and the large number of surviving manuscripts is impressive evidence of the popularity and importance of the book.

In the account that follows, only the briefest summary of the book's contents has been given, for it is such a large and comprehensive work that it could (and should) form the subject of a much longer study.

Contents of K. al-Mi'a

K. al-Mi'a is a large work: the British Library manuscript, on which this study is based, contains 376 folios of small script.[26] It is divided into a hundred chapters or "books", (hence the title), and, as the author says in his introduction, each is meant to be a complete work of its own, not dependent on the others for its understanding. The introduction is long and contains an analysis of the problems which beset the writing of medical books:[27] they

21. This information is supplied by IAU, I, 328. Amīn al-Dawla b. al-Tilmīdh was a distinguished physician of the 12th century, (d.1165), who was chief physician at the ʿAḍudī hospital in Baghdad. (For his biography, see IAU, I, 259-76).

22. Leclerc, *op. cit.*, I, 356-7; Sarton, *op. cit.*, I, 678.

23. This MS., Istanbul, Nuruosmaniye 3557, is described by Dietrich, (A. Dietrich, *Medicinalia Arabica*, Göttingen, Vandenhoeck and Ruprecht, 1966, p. 70). The dating is only presumptive.

24. The manuscript citations for these are to be found in GAL, I, 238; SI, 423; and Sezgin, *op. cit.*, III, 326-7.

25. The most recent is MS. Tehran, Danishkada-i Pizishki, 247/1.

26. This is MS. Or. 6489. It is dated (on f. 194a) as 1105 A. H. (1694 A. D.) and is written in clear, good naskh. It is well preserved but part of the introduction is obliterated and some of the folios of chapter 99 on fractures and dislocations are missing. (See also S. Hamarneh, *Catalogue of the Arabic Manuscripts on Medicine and Pharmacy at the British Library*, Cairo, "Les Editions Universitaires d'Egypt", 1975, pp. 88-90).

27. This was a common format for introductions to compendia of medicine. There was always some fault with the others which the author had decided to rectify in his book. A lengthy critique of other *kunnāshāt*, both Greek and Arabic, is to be found in the introduction to al-Majūsī's *Kāmil*.

b. Muḥammad (992-1009), (the father of Abū'l-ᶜAbbās Ma'mūn b. Ma'mūn mentioned above). Al-Bayhaqī [13] also links al-Masīḥī with this ruler, for he says that the patron of al-Masīḥī was the king of Khwārizm, Ma'mūn b. Muḥammad, to whom he dedicated another of his works, *K. Taᶜbīr al-ru'ya* ("the interpretation of dreams").

As to his dates, there is the usual difficulty with determining these exactly. Wüstenfeld,[14] who describes him as the teacher of Ibn Sīnā, gives his date of death as being around 390/1000, though on what evidence is not clear. Sarton[15] gives a similar date, saying that al-Masīḥī died aged 40 in 999-1000. Leclerc,[16] likewise, puts his date of death at 1000. (It should be pointed out that all these authorities, presumably following Ibn Abī Uṣaybiᶜa, state that al-Masīḥī was Ibn Sīnā's teacher). Brockelmann,[17] however, gives the later date of 401/1010, as does Ullmann.[18] Sezgin[19] cites a manuscript of one of al-Masīḥī's works which is dedicated to Abū'l-ᶜAbbās Ma'mūn (1009-1017). If this is indeed the case, and the book was not in fact dedicated to his father (as noted above on the authority of al-Bayhaqī), then the later date will have to be accepted. It is certain at least that al-Masīḥī was alive in 1002, for it is known that Ibn Sīnā dedicated a missive to him from Jurjān in that year.[20] From this information, all that can be said is that al-Masīḥī was alive in 1002 and died some time after 1009.

Kitāb al-Mi'a fi'l-Ṭibb

Seven works of al-Masīḥī's survive: the best known is *K. al-Mi'a*. It was considered by the famous physician Ibn al-Tilmīdh, who wrote a gloss on it, to have been of the greatest value because it was exact, not repetitious,

13. Ẓahīr al-Dīn al-Bayhaqī, *Ta'rīkh ḥukamā' al-Islām*, ed. M. Kurd ᶜAlī, (Damascus, Maṭbaᶜat al-Ṭaraqī 1946), pp. 88-9.

14. F. Wüstenfeld, *Geschichte der arabischen Aerzte und Naturforscher*, (Göttingen, 1840), p. 59, No. 118.

15. G. Sarton, *Introduction to the History of Science* (Baltimore, Williams and Wilkins, 1927-48), I, 678.

16. L. Leclerc, *Histoire de la Medecine Arabe*, (Paris 1876), I, 356-7.

17. C. Brockelmann, *Geschichte der arabischen Litteratur*, (henceforth: GAL) and *Supplement* (henceforth: S), (Leiden, Brill, 1937-42), I, 238: SI, 423.

18. Ullmann, *op, cit.*, p. 151.

19. F. Sezgin, *Geschichte der arabischen Schrifttums* (Leiden, Brill, 1967), III, 327, No. 6, *Risāla fī taḥqīq sū' al-mizāj mā huwa wa kam aṣnāfuhu*, MS. Shehid Ali, 2095/5.

20. IAU, II, 19, 1.10-11, lists this among Ibn Sīnā's works: "A missive to Abū Sahl al-Masīḥī on the angle, which he wrote in Jurjān". It may be calculated from Ibn Sīnā's autobiography, (*The Life of Ibn Sina*, ed. and transl. by W. E. Gohlman, (State University of New York Press, 1974), that he was in Jurján in 1002.

He describes him as a "practitioner" *(al-mutaṭabbib)* and a logician *(al-manṭiqī)*, presumably implying by the latter description that he was interested in or had written works on logic. He wrote a famous *kunnāsh* called *al-Mi'at maqāla* (more usually known as *Kitāb al-mi'a fi'l-ṭibb*). He died "in middle age" at the age of 40. Ibn Abī Uṣaybiᶜa is able to give more information about him:[8] he praises his skill as a physician and his great learning and stresses his fluency and excellence in the Arabic language, which he wrote with a beautiful hand. Ibn Abī Uṣaybiᶜa says that he examined a copy of al-Masīḥī's book, *Fī Iẓhār ḥikmat Allāh taᶜāla fī khalq al-insān* ("On the Revelation of God's Wisdom in Creating Man"), written in his own handwriting, and was impressed by its excellence of grammar and linguistic precision. He goes on to report what Shaykh Muhadhdhab al-Dīn ᶜAbd al-Raḥīm b. ᶜAlī said of al-Masīḥī: he had never known any Christian physician, either ancient or modern, who could express himself as well as al-Masīḥī. (All this implies that al-Masīḥī's first language was not Arabic, and since he was a Christian, his mother tongue might well have been Syriac; it also implies that Christians in general did not know Arabic well). Then, Ibn Abī Uṣaybiᶜa says that al-Masīḥī is said to have been the teacher of Ibn Sīnā in medicine, and that the latter became proficient in this and in philosophy at his hands, such that he dedicated several books to him.

It is not by any means certain that al-Masīḥī was indeed Ibn Sīnā's teacher. Ibn Sīnā himself asserts in his autobiography that he had no teachers in medicine,[9] not that that necessarily rules it out completely. But al-Qifṭī makes no mention of this claim either.[10] The two men are, however, connected in the Persian 12th-century work, the *Chahār Maqāla*, where the story is recounted that when both of them took flight from the court of the ruler of Khwarizm Abū'l-ᶜAbbās Ma'mūn (1009-1017), they were overtaken by a sandstorm in which al-Masīḥī died.[11] *The Chahār Maqāla* extols the virtues of al-Masīḥī and calls him the successor in philosophy to Aristotle. His book, *Kitāb al-Mi'a*, is recommended as part of the syllabus for medical students.[12]

Ibn Abī Uṣaybiᶜa provides a list of al-Masīḥī's books. He begins with *K. al-Mi'a fi'l-ṭibb*, considered to be the best and most famous of his books. There are three other titles of books on medicine, three on philosophy, and one book, *Fi'l-Wabā'* which he dedicated to the ruler of Khwarizm, Ma'mūn

7. Al-Qifṭī, *Ta'rīkh al-ḥukamā'*, ed. J. Lippert, (Leipzig, 1903), pp. 408-9.

8. IAU, I, 327-8.

9. Al-Qifṭī, *op.cit.*, p. 414.

10. *Ibid*, p. 408.

11. Niẓamī-i ᶜArūḍī. *Chahār Maqāla*, ed. and transl. by E. G. Browne, (Cambridge University Press, 1921), pp. 88-9.

12. *Ibid*, p. 79.

included sections on medical theory, that is: the nature of humours, temperaments, crisis, coction, and so on. Diseases were described in a stereotyped way: cause, symptoms and signs, and therapy. The therapy section was usually the biggest part and often included a number of prescriptions. They also included a section on external or skin diseases, and a section on fevers. Many of them, but not all, also added a usually brief chapter on fractures and dislocations. Many of them also had a section on simple and compound drugs, and on poisons of animal origin or otherwise, and many books included a section on the preservation of health.

Kunnāshāt were used for practical purposes as manuals for medical practitioners and also for the teaching of practitioners and medical students.[4] The relative emphasis on these two functions varied from one *kunnāsh* to another. For example, some *kunnāshāt* were no more than pure manuals of medicine, written in a simple, condensed style with a great deal of detail on therapeutics and very little on medical theory;[5] this type was obviously of use to the practitioner. At the other end of the spectrum, was the type of *kunnāsh* which laid specific emphasis on medical theory, perhaps at the expense of detail on practical procedures, and which favoured a more complicated, intellectual approach; such *kunnāshāt* were useful for teaching purposes and could also be read by the intelligent and educated layman. Abū Sahl al-Masīḥī's *kunnāsh* entitled *Kitāb al-mi'a fi'l-ṭibb* ("The Book of the Hundred on Medicine") is an example of the latter sort.

The study which follows is based entirely on manuscript material, for this worthy and elegant book has never been edited in whole or in part. The 13th-century writer, Nuᶜmān b. ᶜAlī al-Riḍa al-Isrā'īlī, composed a synopsis of it which was edited by Sharafī in 1959.[6] Despite its prestige and popularity (see below), it was never translated either into Latin or into a modern language. Neither, for that matter, were any other of al-Masīḥī's books.

Abū Sahl al-Masīḥī's Biography

Abū Sahl ᶜĪsā b. Yaḥya al-Masīḥī al-Jurjānī was, as is revealed by his name, a Christian and a man of Jurjān in Persia. Al-Qiftī says that he was learned in the sciences of the ancients, and famous among his countrymen.

4. This is made clear in the introductions of many of these books, wherein it is stated that both practitioner and student will benefit from the book: a typical example is Ibn al-Jazzār's introduction to his book, *Zād al-musāfir wa qūt al-ḥāḍir*.

5. Such a book is Ibn Buṭlān's *Kunnāsh al-ruhbān wa'l-adyira*, which is a simple manual of diseases and their treatments.

6. Qadri Sharafī, *Al-Ḥawāshī al-nuᶜmāniyya wa'l-maqāṣid al-ṭibbiyya*, (Hyderabad, 1959). (I have not seen this work). There is a manuscript of the synopsis at the Bibliothèque Nationale, no. 2883. See M. G. de Slane, *Bibliothèque Nationale, Catalogue des Manuscrits Arabes* (Paris, 1883-95), p. 518.

A Mediaeval Compendium of Arabic Medicine: Abū Sahl al-Masīḥī's "Book of the Hundred"*

GHADA KARMI**

Introduction

The *kunnāsh*[1] (or compendium) type of book was very popular among Arabic physicians of the mediaeval period and became the commonest form of medical book to be written. It was supposed to be a comprehensive system of medicine in condensed form, so as to acquaint the reader with all the essentials of medicine without overloading him with too much detail. Many *kunnāshāt* declared this to be their explicit aim in their introductory remarks.[2] As time went on, the *kunnāsh* became the preferred type of medical work, to the despair of such educational purists as Ibn Riḍwān who strongly deprecated the substitution of these derivative works for the original works of the ancients.[3]

These books were not identical either in arrangement or in content, but they resembled each other in certain important respects: they all included at some point a section on diseases arranged from head to toe; many also

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1. The word *kunnāsh* is interesting. It does not appear to be of Arabic derivation, but comes from the Syriac *kunnāsha* (M. Ullmann, *Wörterbuch der klassischen arabischen Sprache*, Vol. I (Wiesbaden, 1970), p. 387, 20 A.

2. For example, ᶜAlī b. al-ᶜAbbās al-Majūsī (fl. 949-982) writes in the introduction to his *kunnāsh*, *Kāmil al-ṣināᶜa al-ṭibbiyya* (Cairo, Bulaq, 1294/1877), Vol. I, p. 7, 1.28f, that he has composed his book:

"That it might be easy (for physicians) to find one book which contains all that is necessary (in medicine). I will not leave out anything that might be needed by students and learned scholars."

3. Ibn Riḍwān was an 11th-century physician of Cairo (d.1061) who took a great interest in the medical education of his day. For his biography, see Ibn Abī Uṣaybiᶜa, *ᶜUyūn al-anbā' fī ṭabaqāt al-aṭibbā'*,(henceforth: IAU) ed. A. Müller, (Königsberg, 1884). He wrote a tract on this subject, *al-Nāfiᶜ fī kayfiyyat taᶜlīm ṣināᶜat al-ṭibb* ("the useful book on the quality of medical education"). The relevant extract is quoted by A. Z. Iskandar in his, "An attempted reconstruction of the late Alexandrian medical curriculum", *Med. Hist.*, 20 (1976), 241.

One wonders whether the *kunnāsh* type of book was not always preferred, almost from the beginning of the translation movement from Greek and Syriac into Arabic. *Kunnāshāt* in Syriac were certainly available before 700 A. D. and came to be written in Arabic from 800 A. D. onwards.

et se l'approprie. Déchaînement d'al-Sijzī qui l'attaque alors avec la dernière véhémence, sans toutefois le nommer. Entre temps al-Qūhī et al-Ṣaghānī étaient entrés en lice et donnaient leurs solutions en 360 H., semble-t-il, celle d'al-Qūhī étant la plus élégante de toutes et antérieure de peu à celle d'al-Ṣaghānī.

La construction de l'heptagone régulier restera une des grandes questions classiques: al-Qūhī en fera l'objet de son deuxième mémoire, Ibn al-Layth en donnera une 2e solution (dans sa 3e lettre). Celui-ci est devenu depuis un géomètre réputé dont al-Bīrūnī et ᶜOmar al-Khayyām feront l'éloge.[9] Ibn al-Haytham donne une solution entre 417 H. et 429 H.[10] Al-Bīrūnī évoque l'heptagone dans "al-Qānūn al-Masᶜūdī, al-Samaw'al b. Yaḥyā dans *Kashf ᶜuwār al-munajjimīn*.[11] L'heptagone donna l'élan vers d'autres tentatives; construction de l'ennéagone régulier,[12] construction du polygone régulier de 11 côtés (qu'Ibn al-Layth crut avoir trouvée), du polygone régulier de 13 côtés, division de l'angle en 5 parties égales.[13] Il reste un des multiples témoins de la faveur que la géométrie a connue dans la 2e moitié du 4e siècle, époque où l'on peut voir la première gestation de l'algèbre géométrique dᶜOmār al-Khayyām.

9. Al-Bīrūnī, *Al-Qānūn al-Masᶜūdī*, (Hyderabad, 1954), vol. 1, p. 297. Al-Khayyām, *Al-jabr w'al-muqābala* Ms. Columbia Univ. Or. Smith 45, 10, pp. 28, 37.

10. Ibn Abī Uṣaybīᶜa, *ᶜUyūn al-anbā'*, (Cairo, 1882), vol. 2, p. 98.

11. Al-Bīrūnī, *ibid* p. 297. Al-Samaw'al b. Yaḥyā, *Kashf ᶜuwār al-munajjimīn*, Ms. Leiden Or. 98, f. 2b.

12. *Al-Qānūn al-Masᶜūdī*, vol. 1, p. 287; voir aussi *al-Rasā'il al-mutafarriqa fi-l-hay'a* (Hyderabad, 1948) , 10, p. 22.

13. Al-Samaw'al b. Yaḥyā, *op. cit.* f. 2l

4 Construction du triangle ABD tel que $\widehat{B} = 2\widehat{A}$ et $\widehat{A} = 2\widehat{D}$ et par suite division du cercle en sept parties égales.

Méthode d'al-Qūhī (1er mémoire)

La division d'un segement AB arbitraire en C et D de sorte que $CB \cdot CD = \overline{AC}^2, AD \cdot AC = \overline{DB}^2$ a donc été opérée. Al-Qūhī a démontré aussi que chacun des segments BD, DC, AC est inférieure à la somme des deux autres. Il peut donc construire le triangle CDE où $DE = DB$ et $CE = AC$.

Je dis que $\widehat{ECD} = 2\ \widehat{EDC} = 4\ \widehat{CED}$. (Par suite si on circonscrit un cercle au triangle CDE on aura la division du cercle en sept parties égales). Prolongeons EC en CF tel que $CF = CD$. On a $BC \cdot CD = \overline{AC}^2 = \overline{CE}^2$ d'où $BC/CE = CE/CD$. Les triangles BCE et DCE sont semblables. D'où $\widehat{B} = \widehat{DEC}$ et $\widehat{CEB} = \widehat{EDC}$. Mais $\widehat{EDC}$ extérieur au triangle BDE égale 2 $\widehat{B}$; donc $\widehat{EDC} = 2\ \widehat{CED}$. De même $\widehat{ECD} = 2\ \widehat{CDF} = 2\ \widehat{CFD}$. Comme $CE = AC$ et $FC = AD$ alors $AD \cdot AC = FE \cdot EC = \overline{DB}^2 = \overline{DE}^2$.

Fig. 6

D'où $\dfrac{FE}{DE} = \dfrac{DE}{EC}$. Les triangles EFD et CED sont semblables d'oû $\widehat{EDC} = \widehat{EFD}$.

Par suite $\widehat{ECD} = 2\ \widehat{EDC}$.

IV

L'historique de la découverte peut être présenté ainsi:

En 358 H., ou peu avant, Ibn al-Layth encore inconnu et qui brûle de percer, donne le premier coup de pioche dans la construction de l'heptagone. Il énonce quatre lemmes, ramène la question à la division d'un segment suivant une certaine relation, et réussit cette division, pense-t-il, par l'intersection de cercles et de droites. Or il est en correspondance avec le jeune mathématicien al-Sijzī. Celui-ci découvre la faute, s'efforce en vain de la corriger et finit par recourir à Abū Saᶜd al-ᶜAlā' ibn Sahl. Ce géomètre y parvient par les sections coniques. Mis au courant, Ibn al-Layth malheureux, de voir l'occasion lui échapper, apporte à la solution quelques modifications insignifiantes

3. *Partage du segment AB par les sections coniques, al-Qūhī (1er mémoire)*

Prenons deux droites perpendiculaires en D et $DA = DS$ (longueur arbitraire). Traçons la parabole d'axe SD, de sommet S et passant par A. Traçons l'hyperbole équilatère de sommets D et A et d'axe AD. Elle coupe le parabole en M dont la projection est E sur AD, et L sur SD. Prenons $AB = DL$ sur le prolongement de DA.

Dans la parabole $\overline{ML}^2 = SD{\cdot}SL$ ou $\overline{ED}^2 = DA{\cdot}DB$

Dans l'hyperbole $\overline{ME}^2 = DE{\cdot}AE$ ou $\overline{AB}^2 = DE{\cdot}EA$

Ainsi un segment BE a été divisé dans les conditions voulues.

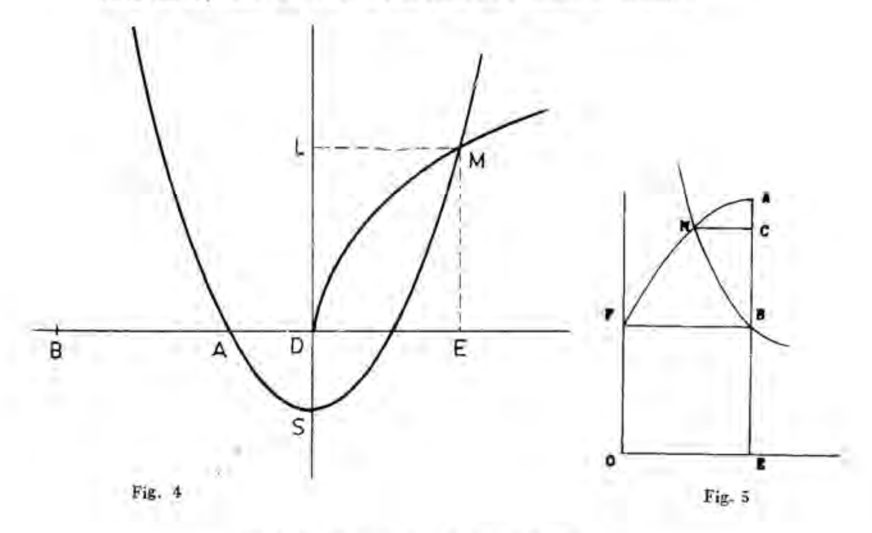


Fig. 4

Fig. 5

Méthode d'al-Sijzī et d'Ibn al-Layth

Sur le prolongement du côté EB du carré $OEBF$ on prend $BA = EB$. On trace la parabole d'axe AB, de sommet A passant par F. (Donc dans l'équation de la parabole $y^2 = 2\,px$, $2p = AB$). On trace aussi l'hyperbole d'asymptotes OE, OF passant par B. Elle coupe la parabole en M qui se projette en C sur AB. Posons $BE = BF = BA = a$, M appartenant à l'hyperbole $(a + BC)\,(a - MC) = a^2$ d'où $aBC = (a + BC)\,MC$.

Comme M appartient à la parabole $MC = \sqrt{AC{\cdot}AB}$. Par suite AB est divisé en C suivant la condition voulue.

III

Contenu mathématique des mémoires

Pour construire l'heptagone régulier il s'agit de diviser un cercle en 7 parties égales.

1. (1) Archimède suivi par al-Qūhī (premier mémoire) et al-Ṣaghānī se propose de construire le triangle ABD où $\widehat{B} = 2\widehat{A}$ et $\widehat{A} = 2\widehat{D}$.

(2) *Al-Qūhī* (2e mémoire) veut construire le triangle ABG où $\widehat{A} = 5\widehat{B} = 5\widehat{G}$.

(3) *Ibn al-Layth et al-Sijzi* construisent ADE où $\widehat{D} = \widehat{E} = 3\widehat{A}$.

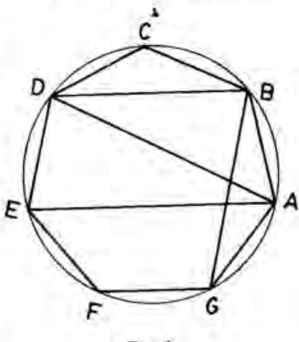


Fig. 1

2. Dans une 2e étape, les égalités entre les angles vont céder la place à des égalités entre les côtés.

Archimède et al-Qūhi (1er et 2e mémoires) et al-Ṣaghānī aboutissent à division d'un segment en trois parties (voir début de l'article). Donnons la méthode d'al-Qūhī (2e mémoire).

Dans le triangle ABC, $\widehat{A} = 5\widehat{B} = 5\widehat{C}$, nous prolongeons BA en ADE de sorte que $\widehat{ACD} = \widehat{ACB}$ et $DC = DE$. Les triangles semblables EDC et ECA, ADC et DBC donnent:

$$ED \cdot EA = \overline{EC}^2 = \overline{AC}^2 = \overline{AB}^2$$

$$DA \cdot DB = \overline{CD}^2 = \overline{DE}^2$$

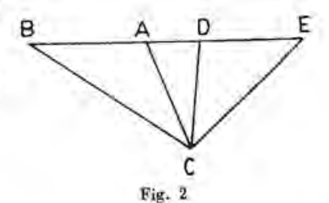


Fig. 2

Ibn al-Layth (dans mémoire perdu) et al-Sijzī remplaçent la relation angulaire (3) par la divison de AB en deux segments AC et BC tels que

$$\frac{\sqrt{AB \cdot AC}}{BC} = \frac{AB}{AB + BC}.$$

Ibn al-Layth indique dans sa 2e lettre une autre division de AB en C et D.

telle que $AB \cdot DB = \overline{AC}^2$

$CB \cdot CD = \overline{AC}^2$

B D C A

Fig. 3

la course fiévreuse vers le but, les chutes, les arrêts forcés, voire les irrégularités ne vont pas manquer: toutes circonstances qui donneront lieu à une querelle de priorité sur laquelle se greffe pour l'exacerber la vieille "Querelle des Anciens et des Modernes". Dans le brouhaha des revendications contradictoires et des anathèmes qui vont s'élever, nous avons pour interprète et guide précieux sinon impartial, un géomètre attardé al-Shannī[8] qui s'est intéressé à la querelle et en connaît bien les dessous.

II

Les mémoires à verser au dossier du procès sont:

1°) Une première lettre d'Abūl'-Jūd ibn al-Layth, adressée en 358 H. à Abūl-Ḥusayn ʿUbayd Allāh b. Aḥmad, dont copie adressée à Abū M. ʿAbdallāh b. ʿAli al-Ḥāsib. Cette lettre est perdue mais son contenu nous est révélé par les lettres 2 et 3 d'Ibn al-Layth, 4 d'al-Sijzī, 8 d'al-Shannī.

2°) Lettre adressé par Ibn al-Layth à Abū M. ʿAbdallāh b. ʿAlī al-Ḥāsib. L'auteur y analyse les solutions d'al-Qūhī et d'al-Ṣaghānī et la sienne propre. (Ms Paris 4821, f.37ᵇ–46ᵃ.)

3°) Lettre d'Ibn al-Layth à Abū'l-Ḥasan Aḥmad b. Isḥāq, plusieurs années après la clôture de la querelle (Ms Caire 7805, f. 117ᵇ - 120ᵃ.)

4°) Mémoire d'al-Sijzī sur la construction de l'heptagone régulier et la trisection de l'angle; (Ms Paris 4821, f.10ᵇ–16ᵇ; le même que Caire 7805 f. 113 – 117.)

5°) Mémoire d'al-Qūhī dédié à ʿAḍud al-Dawla. (Ms Paris 4821, 17ᵇ - 23ᵇ ; Caire 7804 f. 222ᵇ - 225ᵃ. La dédicace au roi dans le ms. Caire est très embellie).

6°) 2ᵉ mémoire d'al-Qūhī dédié à Abū'l-Fawāris b. ʿAḍud al-Dawla postérieur au précédent et tout à fait différent. (Ms Paris 4821, f. 1ᵇ - 8ᵃ).

7°) Mémoire d'al-Ṣaghānī dédié à ʿAḍud al-Dawla. Il y est fait mention d'un mémoire antérieur présenté au roi à Rayy et dont le mémoire actuel est un remaniement. La date de résolution d'une proposition du mémoire est fixée au 12.X.360 H. (Ms Paris 4821, 23ᵇ - 28ᵇ.)

8°) Mémoire d'al-Shannī, *Kitāb kashf tamwīh Abū'l-Jūd* (Ms Caire 780, f. 129ᵇ-134ᵇ). Al-Shannī relate les circonstances de la découverte de la solution, les erreurs d'Abu'l-Jūd et analyse les solutions.

De ces mémoires, C. Schoy a étudié en 1926, la construction de l'heptagone par al-Sijzī (*Isis*, 8 (1926), 21-35), et Y. Samplonius, en 1963, celle d'al-Qūhī (*Janus* 50 (1963), 227-249, d'après F. Sezgin, *GAS*, V, p. 318, 3ᵉ).

8. *Ibid*, p. 352.

This is a French version of a paper which appeared in Arabic in JHAS, 1 (1977), 352-384. Its present form makes the results available to a wider circle of readers.

Construction de l'heptagone régulier par les Arabes au 4ᵉ siècle de l'hégire

ADEL ANBOUBA*

I

Au 3ᵉ siècle H., Thābit b. Qurra traduit un mémoire d'Archimède sur l'heptagone régulier dont le texte grec est actuellement perdu.[1] La solution d'Archimède revient à diviser un segment AB en deux points C et D de sorte que

$$(AC + CD) \cdot CD = \overline{DB}^2$$
$$(CD + DB) \cdot DB = \overline{AC}^2$$

B D C A

ce qu'Archimède résout par le procédé de "la règle mobile" et non par la géométrie fixe.[2] On sait que la construction de l'heptagone régulier mène à une équation du 3ᵉ degré et par conséquent, ne peut résolue par intersection de cercles et de droites.

La question en reste là jusque vers le milieu du 4ᵉ siècle H. A cette époque un intense bouillonnement agite la vie scientifique arabe, exalté par la dynastie Bouyide. Quatre géomètres de valeur vont s'attaquer à la construction de l'heptagone. Ce sont:

1. Abū'l-Jūd M. b. al-Layth[3]
2. Abū Saᶜīd Aḥmad b. M. ᶜAbd al-Jalīl al-Sijzī[4]
3. Abū Sahl Wayjan b. Rustam al-Qūhī[5]
4. Abū Ḥāmid Aḥmad b. M. b. al-Ḥusayn al-Ṣaghānī[6]

En coulisse se tient un géomètre éminent dont l'intervention auprès d'Ibn al-Layth et d'al-Sijzī sera décisive: Abū Saᶜd al-ᶜAlā' b. Sahl.[7] Dans

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1. T. L. Heath, *A Manual of Greek Mathematics*, (Oxford, 1931), pp. 283-286.
2. *Ibid.* pp. 340-342.
3. F. Sezgin, *Geschichte des arabischen Schrifttums*, Bd. V (Leiden, E. V. Brill, 1974), pp. 353-355 (où l'on trouvera toutes références utiles).
4. *Ibid.* pp. 329-334.
5. *Ibid.* pp. 314-321, 403.
6. *Ibid.* p. 311.
7. *Ibid.* pp 341-342.

The intersection of any circular cone or cylinder with a plane parallel to the base is also a circle. And the line drawn from the vertex to the center of the base passes through the center of the intersection.

The proposition is followed by an example with proof, but no drawing.

References

Yvonne Dold-Samplonius, *Book of Assumptions by Aqāṭun* (Doctoral Thesis, Amsterdam, 1977).

Max Krause, "Stambuler Handschriften islamischer Mathematiker", *Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik*, Abt. B, vol. 3 (Berlin, 1934), 437-532.

Carlo A. Nallino, "Tracce di opere greche giunte agli Arabi per trafila pehlevica", *A Volume of Oriental Studies Presented to Edward G. Browne*, T. W. Arnold and R. A. Nicholson eds. (Cambridge, 1922), 345-363.

Ibn al-Qifṭī, *Ta'rikh al-ḥukamā'*, Julius Lippert ed. (Leipzig, 1903).

Fuat Sezgin, *Geschichte des arabischen Schrifttums*. Band V, Mathematik. Bis ca. 430 H. (Leiden, 1974).

Manfred Ullmann, "Der Werwolf", *Wiener Zeitschrift für die Kunde des Morgenlandes*, 68 (1976), 171-184

with an article in the last two marginal notes (fol. 102v). Aflāṭūn is never written with an article. Van Ess adds that in general an article with the name of an ancient author is somewhat curious. As the addition "translated from the Greek language" has been omitted in the Istanbul manuscript, its redactor may not have recognized Aqāṭun as an ancient Greek author. As the name Aqāṭun occurs, according to Lippert in this same form in all codices of the *Ta'rīkh al-ḥukamā'* (p.195), I assume its writing to be correct. This would point to a Greek name like ῾Εκατον. A more probable Greek name would be ᾿Αγαθων. However, this means three exceptions in one word from the normal rules of transliteration. M. Ullmann has shown that the Greek word λυκανθρωπος (werewolf) became *quṭrub* in Arabic by means of a Syrian intermediary, in which θ was already rendered by *ṭ*. In our case he also suggested an intermediary, namely Pahlavi (= the Iranian language of Sassanid Persia). D. N. MacKenzie and W. Sundermann agreed with this eventual possibility, and gave more details:

Although one expects *g* in Pahlavi for γ, *k* sometimes occurs *(hykmun* for ἡγεμόν*)*. Then ᾿Αγαθων could have been rendered by **'k'twn*, which would have to be written in Arabic as **'q'ṭwn*. Because of the ambiguity of some Pahlavi letters, the ending – *wn* could have been misread as -*n*'. In this way one could arrive at *'q'ṭn*, Aqāṭun. Already C. A. Nallino pointed out that scientific works were translated from Greek into Pahlavi into Arabic. He notes in this context that the extreme ambiguity of Pahlavi writing makes it impossible to read foreign names with certainty. A. Schall comments that the rules in everyday life are not so strict: the correlation γ ∼ ق (*q*) still exists in dialects, especially in names, e.g. (Jordan:) قسّوس (priest) is rendered by Goussous, and (Sudan:) عبد القادر by Abdel Gadir. ᾿Αγαθων was a rather common Greek name, but no mention of a mathematician of this name has been transmitted to us.

Appendix

Among the pages of the treatise one, fol. 95, does not belong to the text, which after fol. 94v continues on fol. 96r. This page may belong to another treatise of the manuscript, as it contains on one side, fol. 95v, a referential proposition which has no apparent connection with the contents of the *Kitāb al-mafrūḍāt*. It is written in the same hand as our treatise. Fol. 95r consists of two three-dimensional drawings not belonging to the proposition on fol. 95v. Seemingly they are not of an astronomical nature.

The proposition on fol. 95v reads: Proposition by Muḥammad ibn Mūsā from the book "On the Sphere", which refers to it:

His name is given as Muḥammad ibn Sartāq from Marāgha. It is remarked that he has studied this book by Aqāṭun, has verified and corrected it. The redactor is not otherwise known to us.

To the title of the Bankipore manuscript is added "Thābit ibn Qurra translated the treatise from the Greek language into the Arabic language". This leads to the question of what the original Greek title may have been, and the Greek spelling of Aqāṭun [On author and title see thesis, Chapter II]. The suppositions were excluded from the thesis, as no definitive answer can be given. The hypotheses are laid down in the following.

a. *The Title*

In the Arabic sources we find the titles *Kitāb al-ma'khūdhāt*, *Kitāb al-mu^cṭayāt*, *Kitāb al-mafrūḍāt*. The first of these is connected with the verb *akhadha* (أخذ) with basic meaning "to take". This corresponds with the Greek verb λαβειν. Also the original meaning of *ma'khūdhāt*, i. e. takings, receipts, returns (commerce) and of λημματα are equivalent. Thus *Kitāb al-ma'khūdhāt*, refers to the Greek title "Lemmata", e. g. Archimedes.

The second title, *Kitāb al-mu*^{c}*ṭayāt* is related to the verb *a*^{c}*ṭaya* (عطى IV) which means "to present, offer". The corresponding Greek verb is διδοναι. Thus *Kitāb al-mu*^{c}*ṭayāt* is the translation of the Greek title δεδόμενα, e. g. Euclid's Data.

As for the title *Kitāb al-mafrūḍāt*: in the case of Thābit ibn Qurra this title is sometimes translated as "Data". As I pointed out above, Data has usually a different Arabic equivalent. Therefore I tried to find another possible Greek title. *Mafrūḍāt* is a form of the verb farada (فرض) meaning something like "to decide, impose, assume, suppose, postulate". This could be rendered by the Greek verb υποτιθεσθαι (inf. med.), and thus *mafrūḍāt* could be a translation of υπόθεσεις. To this E. M. Bruins objects that nowadays the Arabic word for assumption, supposition, hypothesis is *iftirāḍ*. He therefore suggests starting from a more special meaning of *farada*, namely "to take for granted". This could then correspond with the Greek verb συγχωρεω and we could assume *mafrūḍāt* to be a translation of συγχωρησεις.

This small exposition may have made clear how difficult it is, if not impossible, to establish the original Greek title.

b. *The Author*

The author's Greek name, which was arabized into Aqāṭun can only be guessed at. Some want to explain Aqāṭun as a misreading of Aflāṭūn (= Plato). According to J. van Ess this cannot be correct as Aqāṭun is written

Prop. 40: (= Prop. 43): If in the right-angled triangle ABG with angle ABG right, angle BAG is bisected by line AD, line AE drawn at random, from point E line EZ constructed parallel to line AD, ZB joined cutting AD in T, and ET joined, then AZ : ZT = AE : ET.

Prop. 41 (1) Let in the right-angled triangle ABG, with angle BAG right, from point A to line BG the lines AD and AE be drawn such that angle DAG is equal to angle GAE, then BE : EG = BD : DG.

(2): Conversely: If BE: EG = BD: DG [and angle BAG be right], then ∢ DAG = ∢ GAE.

(3): (margin) Let ∢ EAG = ∢ GAD, and BD: DG = BE :EG, then ∡ GAB = 90°.

Prop. 42 Let in triangle ABG angle B be bisected by line BD and angle G by line GD, then angle A is bisected by line AD.

Prop. 43 is identical with Prop. 40 but has been proved in a different way. Here Propositions 41 and 42 are used, whereas for the proof of Prop. 40 Propositions 38 and 39 are applied.

From these contents the impression is gained that Aqāṭun made an effort to understand plane geometry. Maybe this was done in a school where this treatise served as a textbook or exercise book. In this case, however, one would suppose more copies of the treatise to be extant. It seems therefore more probable to me that this was a one-man effort. Aqāṭun worked out new propositions and also, like Pappus, gave some proofs that had been left out in the existing mathematical literature, but no references are added. There may have been a mutual influence between Pappus and Aqāṭun. Other mathematicians exercising an influence on our author appear to be Archimedes, Euclid, and Apollonius. Also a connection with Menelaus exists: propositions 33 and 34 contain two special cases of Menelaus' theorem in the plane. Some of the propositions in the *Kitāb al-mafrūḍāt* may be later Arabic insertions [Thesis, Chapter I].

As the treatise is only moderately original, which may be the reason why not many copies seem to have existed, its impact on later mathematics was small. The only connection found is in Ibn al-Haytham. An interesting feature of our copy are the marginal notes. In these notes improvements on the text are made, i. e. some missing words are inserted and some different proofs added. This is done conscientiously and with great care. E.g. in the case of Prop. 6 the addition ends "I had written down this remark before looking at the construction of the proof. So I apologize." The marginal notes at the beginning and the end of the treatise inform us about the redactor.

Prop. 31: If the tangents ED and EA to circle ABTD be drawn, and if an arbitrary line EZ be drawn cutting the circle at Z and B; if AD be joined, if to EZ the perpendicular ZT be drawn cutting AD in Y and the circle in T, and if EY and ZD be joined, then $\sphericalangle$ DEY = 2 $\sphericalangle$ DZT.

Prop. 32: If to the semicircle with diameter AG the tangents EA and EB be drawn, EB and AG be extended until the intersection point D, if BZ be drawn parallel to AD, DZ and AB be joined intersecting in H, and HT be drawn perpendicular to AG, then T is the center of the circle.

Prop. 33: If line AG of triangle ABG be bisected at D, line BA be extended to E, and ED be joined and extended to Z on line BG, then BE : EA = BZ : ZG.

Conversely, if BE : EA = BZ : ZG, then AD = DG.

Prop. 34: If line BA of triangle ABG be extended from A to E, line BG bisected at Z, and line AG divided at D such that BE : EA = GD : DA, then E, D, Z are collinear.

Prop. 35: Through point D outside line AB let the lines ED and DZ be drawn both parallel to line AB, then EDZ is a straight line.

Prop. 36: From point E let the lines EZ and ED be drawn cutting the lines AB, AG, AD respectively in Z, T, L and in B, G, D, and let EZ : ZT = EL : LT, then EB : BG = ED : DG.

Prop. 37: In the right-angled triangle ABG, with angle BAG right, let the lines AD and AE be drawn such that angle DAE is equal to angle ABG, and from point B let the perpendicular BZ to AE [cutting AD in T] be drawn and extended to H on AG. Then DA·AT + GB·BD = HB·BT + GA·AH; and secondly GB·BD + GA·AH = AB^2· DA·AT + GB·BD = HB.BT + GA.AH.

Prop. 38 (1): Let the lines AB, AG, AD be of equal length and DG, GB, BD be joined, then $\sphericalangle$ GBA + $\sphericalangle$ GDB = 90°.

(2): Moreover, if AB = AG and $\sphericalangle$GBA + $\sphericalangle$GDB = 90°, then the lines AB, AG, AD are of equal length.

(3): Also, if AD = AB and $\sphericalangle$ GBA + $\sphericalangle$ GDB = 90°, then the lines AD, AG, AB are of equal length.

(4): Finally, if AD = AG and $\sphericalangle$ GBA + $\sphericalangle$ GDB = 90°, then the lines AD, AG, AB are of equal length.

Prop. 39: If in triangle ABG line AD is drawn meeting BG in D such that angle DAG is equal to angle ABG, then

$$BG : GD = BG^2 : GA^2 = BA^2 : AD^2.$$

Prop. 20: If in the isosceles triangle ABG, with AB equal to AG, lines AE and AD be drawn, meeting BG at E and D such that $BD \cdot DG : DA^2 = GE \cdot EB : EA^2$, then DA = AE.

Prop. 21: Let in triangle ABG angle BAG be bisected by line AD, meeting BG at D, then $(BA + AG) : GB = AB : BD$.

Prop. 22: Let from triangle ABG AB be extended to D and AG to E, let DH be drawn parallel to EB and EZ parallel to DG, then ZH will be parallel to BG.

Prop. 23: Let in triangle ABG AD be equal to BE and AZ equal to GH, let GE, GD, BZ, BH be joined, GE and BZ intersecting in W and GD and BH in S. If AS and AW be joined and extended meeting BG in T and Y, then BT is equal to GY.

Prop. 24: Let angle AGB in the right-angled triangle ABG, with angle ABG right, be bisected by line GD, and angle DAE be equal either to angle AGD or angle BGD, then $GD > GE$.

Prop. 25: Let angle AGB in the right-angled triangle ABG, with angle ABG right, be divided by line GD such that angle BGD is twice angle DGA, then $BG \cdot GA > GD^2$.

Prop. 26: Let in the semicircle with diameter AD arc AB be equal to arc BG, let GD be joined, and BE be drawn perpendicular to AD, then $GD < ED$.

Prop. 27: If in triangle ABG BG be bisected at D and AD be joined. If from B an arbitrary line be drawn cutting AD in Z and AG in E, and GZ be joined and extended to H on AB, then, if HE be joined, it is parallel to BG.

Prop. 28: If in the circle-segment standing on line BG arc BG be bisected at A, E be taken on the extension of BG, and AG and AE cutting the segment at D be joined, then $EA \cdot AD = AG^2$.

Prop. 29: If through two circles intersecting in A and D, an arbitrary line be drawn cutting one circle in Z and H and the other in B and E, and ZA, AB, ED, DH be joined, then $\sphericalangle ZAB = \sphericalangle EDH$.

Secondly, if HD and ZA be extended to K and T on circle ABED, and BK and ET be joined intersecting in L, then BL = LE.

Prop. 30: If from triangle ABG with angle BAG right, BA be extended to D, and from D, DE be drawn perpendicular to BG cutting AG in Z, then $BD \cdot DA = GZ \cdot ZA + ZD^2$.

Conversely: If $BD \cdot DA = GZ \cdot ZA + ZD^2$, then $\sphericalangle DEB = 90^\circ$.

Prop. 6: If BG is the diameter of a semicircle, and the chords AG, BD meet in Z, and if BA, GD be drawn meeting in E, then $BD \cdot DZ = GD \cdot DE$.

Prop. 7: Let BG be the diameter of a semicircle, and the chords AG, BD meet in Y. Take Z on BD and E on AG so that $BD \cdot DY = DZ^2$ and $GA \cdot AY = AE^2$, and let EB, ZG be joined meeting in H, then $ZH = HE$.

Prop. 8: In the equilateral triangle ABG the heights AZ, BD, GE are of equal length.

Prop. 9: Let ABG be an equilateral triangle, and AD its height. Let from a point E on BD the perpendiculars EZ and EH be drawn to the sides GA and AB, then $AD = EZ + EH$.

Prop. 10: Let ABG be an equilateral triangle, and AD its height. Let from an interior point E the perpendiculars to the sides EZ, EH, ET be drawn, then $AD = EZ + EH + ET$.

Prop. 11: If in triangle ABG the line AD be drawn meeting BG at D such that angle BAD be equal to angle AGD, then $GB \cdot BD = AB^2$.

Prop. 12: Let in triangle ABG, with AB equal to AG, AD be drawn perpendicular to AB meeting the extension of BG in D. If AB be bisected at E and ED be joined cutting AG at Z, and if through Z, HZ be drawn parallel to AB, then $DA \cdot AH = AG^2$.

Prop. 13: If in triangle ABG, with AB equal to AG, AD be drawn perpendicular to BG, then $2\ DG \cdot GB = AG^2$.

Prop. 14: If in triangle ABG the perpendicular AD to BG be drawn, then $BD^2 - DG^2 = BA^2 - AG^2$.

Prop. 15: Let line AB be equal to line AG and line BD equal to line DG, and let both angles BAG and BDG be right, then $\sphericalangle ABD = \sphericalangle AGD$.

Prop. 16: Let A be the right angle of the right-angled triangle ABG. If BG be bisected at D and AD be joined, then $BD = DG = DA$.

Prop. 17: Let in the right-angled triangle ABG, with angle BAG right, on the extension of AG a point D be taken, from which DE is drawn perpendicular to BG and cutting AB at Z. Let GZ be joined and on it H be taken such that $BH^2 = AB \cdot BZ$ and let DH be joined, then $DH^2 = DE \cdot ZD$.

Prop. 18: Let the lines AB and BG meet at B, and on AB point D be taken, such that $AB^2 = AD^2 + BG^2$. Let DG be joined and bisected at E, and AE be joined, then $\sphericalangle DAE = \sphericalangle DGB$.

Prop. 19: If in the isosceles triangle ABG, with AB equal to AG, an arbitrary line AD be drawn cutting BG at D, then $BD \cdot DG + DA^2 = AG^2$.

manuscript 2468,29 (fol. 141r – 144v) [Sezgin, p. 135]. An Arabic edition of the latter together with Bankipore 2468,28 (fol. 134v – 141r, *Kitāb Arshimīdis fī'l-dawā'ir al-mutamāssa*, has been published by the Osmania Oriental Publications Bureau (Hyderabad-Dn., 1947).

In the Aya Sofia manuscript the date of copying is given as ca. A. D. 1230,mentioning as place of copying,sometimes Damascus, sometimes Marāgha. At the end of the Bankipore manuscript the date of its composition is indicated as A. D. 1027/1028. In the present copy some of the treatises are dated Mosul A. D. 1234/35. Thus the present copies of both treatises date from the same period. Both are written in Naskhī. The mathematical quality of the treatise is higher in the Aya Sofia manuscript than in the Bankipore manuscript.

The reasons for accepting the title *Kitāb al-mafrūḍāt* and Aqāṭun as its author are laid down in Chapter II of the thesis.

The Contents [*Thesis, Chapter III*]

Prop.1: If the base BG of the circle-segment ABG be extended in either direction with pieces of equal length, and from the endpoints D and E the tangents EZ and DH be drawn to the segment, then the line ZH connecting the tangential points is parallel to the line ED.

Prop. 2: Assume the two lines DB and DG are tangents to a circle. Let the chord BG connecting the tangential points be extended to E, and let from E a third tangent be drawn, touching at A and meeting DG in Z and BD in T, then TE : EZ = TA : AZ.

Prop. 3: Assume the two lines EG and ED are tangents to a circle, while EB cuts it at H and B. Let DA be the chord through D parallel to EB, and let AG meet BH in Z. Then BZ = ZH.

Remark: There is no drawing in the Aya Sofia manuscript as the room left open for this purpose is too little. Later I discovered that the drawing had been made on a loose leaflet which lies now, on the microfilm, between fol. 87v and fol. 88r.

Prop. 4: Let ABG be an isosceles triangle and AD the perpendicular to the base BG. Assume on AB the points Z, E such that $BD^2 = BE \cdot BZ$. Let ZD be joined, ZH be drawn parallel to BG, and EH be joined, then $\sphericalangle EHG = 2 \sphericalangle AZD$.

Prop. 5: If AG is the diameter of a semicircle and B the middle of the arc AG; let from D, on the extension of AG, DB be joined cutting the circle at Y. If YE = EB and from the center Z, ZE be drawn until it meets the extension of AB in H, then AH : HB = DZ : ZB.

Some Remarks on the "Book of Assumptions by Aqāṭun"

Yvonne Dold-Samplonius*

Introduction and Conclusion

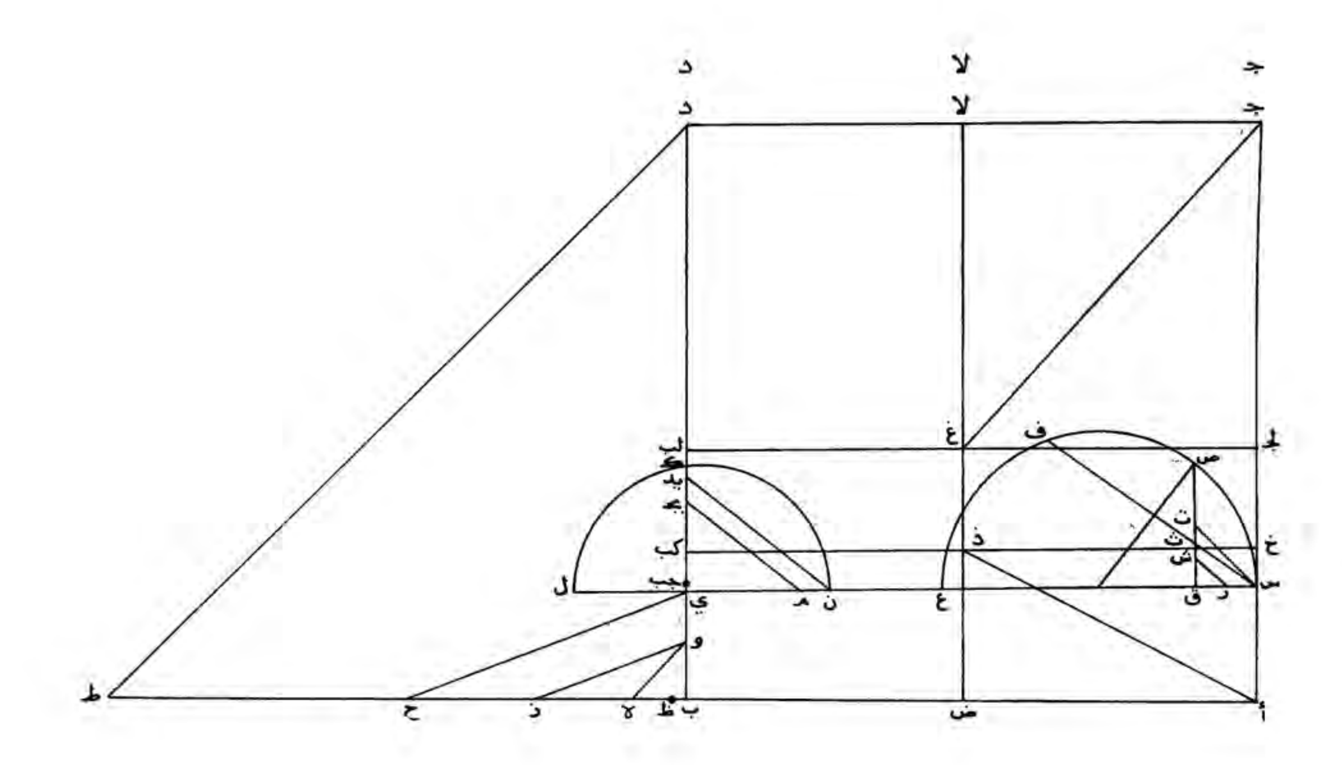
The treatise *Kitāb al-mafrūḍāt li Aqāṭun* (Book of Assumptions by Aqāṭun) has been treated in full in my doctoral thesis (Amsterdam, 1977). The present paper contains an abstract of this thesis. It consists of the contents of the treatise, i.e. propositions only without either proofs or drawings, along with some remarks describing the manuscript and pointing out several influences. In addition the questions of the original Greek title and putative Greek name of the author are extensively discussed. The offered solution is, however, too vague to have been included in the thesis.

My conclusion is that the treatise contains interesting propositions, but no sensational theorems. Some propositions deal with fundamental properties of triangles, some go in the direction of trigonometry, others could be connected with optics. The author, i.e. Aqāṭun seems to have been a man with a good knowledge of the mathematical literature, judging from the different influences on his treatise [Thesis, Chapter IV]. He may have lived around the same time as Pappus: on the one hand Aqāṭun gives two converses to a lemma by Pappus (prop. 41), on the other hand both Pappus and Aqāṭun prove a lemma related to Apollonius' *Conics* (prop. 27) and a lemma connected with Euclid's *Porisms* (prop. 22); these proofs by Aqāṭun and Pappus are similar but not identical. The treatise was still of value and interest to Arabic mathematicians in the thirteenth century, according to the extensive marginal notes. Yet the sphere of influence apparently was not very large.

Description of the Manuscript [Thesis, Chapter I]

The treatise "Book of Assumptions by Aqāṭun", *Kitāb al-mafrūḍāt li Aqāṭun*, is contained in the Istanbul manuscript Aya Sofia 4830,5 (fol. 89v–102v) [Krause, p. 439]. It consists of 43 propositions dealing with plane geometry. Nineteen propositions, all from the first half, form a separate treatise entitled "Book by Archimedes on the Elements of Geometry", *Kitāb Arshimīdis fī'l-uṣūl al-handasīya*. This is contained in the Bankipore

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هذا الشكل ويصفح عن السهو القليل إن وقع(١٠٨) في بعض حسباناتها الجزئية فقط ، وإن عثر على خطأ في بعض براهينه فينبهنا(١٠٩) عليه مفيدا ادّعاءه(١١٠) فقد(١١١) عمي علينا لكثرة المقدمات واختلاط الهندسية فيها بالحساب ، ولا ينكر كثرة التطويل في مقدماتها فإن الوصول [redacted] إلى المطلوب البرهاني بكثرة المقدمات < و > بالمتوسطة مع العصمة من الغلط إن كانت يكون(١١٢) إليه بالدربة والارتياض ، وأدل على < أن > الإصابة في المعقولات يُكثر بالضرورة مقدمات براهينها ومتوسطاتها ، وأعظم فوائد العلوم الرياضية إنما هو ذلك ، ولقد(١١٣) تحيّزت عن التطويل في مقدمات براهين هذا الشكل مع كونها حقا ضرورية(١١٤) في إفادة النتيجة المطلوبة ، ثم إن أشار المخدوم المنعم فسأعرض سائر الطرق(١١٥) ، على رأيه الناقد العالي إن شاء الله تعالى ،

والسلام(١١٦) .

١٠٨ – ك ، ل : وقعت ١٠٩ – ك : مسهبا ١١٠ – ل : ادعاه ، ك : لدعاة والمقصود ما ذهب إليه
١١١ – ك ، ل : قد ١١٢ – ل : ناقصة ١١٣ – ك ، ل : ولهذا ١١٤ – ك ، ل : ضروريا
١١٥ – ك : الطرف ١١٦ – ل : والحمد لله وحده

مـــن أحد عشر جزءا ونصفه عشرة أجزاء من أحد عشر جزءا من الواحد وإذا[٨٨] قسمنا العشرة بأحد عشر قسما يكون كل قسم عشرة أجزاء مـــن أحد عشر من الواحد فخط ب ى جزآن من أحد عشر جزءا من ب د العشرة وسطح ب س[٨٩] من سطح ب ج يكون على هذه النسبة، فمنحرف ا ذ كب ب[٩٠] جزآن من أحد عشر جزءا من مربع اب جد . ولأن نسبة منحرف ا ذكب ب[٩٠] إلى منحرف جد لب غ كنسبة قاعدة ب كب إلى قاعدة لب د — وبالمقدار الذي به ب كب اثنان فلب د خمسة لأنه[٩١] مثلاه ومثل نصفه— فيكون منحرف جد لب غ خمسة أجزاء من أحد عشر جزءا من المربع الكبير. ولأن نسبة مثلث ا ض ذ[٩٢] المساوي لمستطيل خ ى[٩٣] إلى مثلث جغ لا[٩٤] كنسبـــة قاعدة ض ذ[٩٥] إلى قاعدة غ لا ، وهو مثلان ونصف ، فيكون مثلث جغ لا / [redacted] مثلي ونصف[٩٦] ا ض ذ[٩٢] ومجموعهما ثلاثة أمثال ونصف مستطيل خ ى[٩٧] . ولأن مستطيل ا لا مركب من ضرب ضلع المربع الكبير في جزأي ا ض —وأحدهما[٩٨] مثل ونصف ب ى والأخر ثلاثة أمثال ونصف خ س[٩٩] وذلك يساوي مجموع المثلثين < ومنحرف جغ ذ ا > — فاذا فصلنا المثلثين من سطح ا لا فكأنا قد فصلنا منه سطح ضلع المربع الكبير في ثلاثة أمثال ونصف خ س[٩٩]، فيكون منحرف جغ ذ ا[١٠٠] مساويا لضرب ضلع المربع الكبير في مثل ونصف ب ى . فمنحرف جغ ذ ا[١٠١] مثل ونصف سطح ب س أي منحرف ا ذ كب ب[١٠٢]، فبالمقدار الذي به يكون منحرف[١٠٣] / جد لب غ خمسة يبقى[١٠٤] سطح غ لب كب ذ[١٠٥] واحدا[١٠٦]، وهو واحد وهو المطلوب.

والمأمول من كرم المخدوم والمنعم أدام الله علوه أن ينعم بالنظر[١٠٧] والتأمل في

٨٨ – ل : وإذ ٨٩ – ل : ر س ٩٠ – ك ، ل : ا ظ كب ب ٩١ – ك ، ل : لأن مثليه
٩٢ – ك ، ل : ا ض ظ ٩٣ – ك ، ل : ح ى ٩٤ – ك ، ل : وغ لا ٩٥ – ك ، ل . ض ط
٩٦ ، – ك : أضافها الناسخ في الهامش ٩٧ – ك ، ل : ح ى ٩٨ – ك ، ل : أحدهما
٩٩ – ك ، ل ح س ١٠٠ – ك ، ل : جع ظ ا ١٠١ – ك جغ ظ ا ، ل جع ظ ا
١٠٢ – ك : ا ظ كب ب ، ل : ا ط كب ب ١٠٣ – ك : ومنحرف ١٠٤ – ك ، ل ويبقى
١٠٥ – ك : غ لب كب ظ ، ل : ع لب كب ط ١٠٦ – ك ، ل : واحد
١٠٧ كذا في الاصل والمعروف أن فعل « أنعم » يتعدى بنفسه فيقال «أنعم النظر في كذا»— انظر معجم «متن اللغة »

الآخر أربعة و ٣٠ من ٥٥ من الواحد وهو سطح ع كب الباقي . ولأن سطح خ ض[٦٣] هو [٦٤] ضرب ا خ[٦٥] في ا ض[٦٦] و ا خ[٦٧] يساوي ب كب — وهو واحد وتسعة أجزاء من أحد عشر جزءا من واحد مع زيادة خ س[٦٨] أي ر س — وضلع ا ض[٦٩] هو[٧٠] مثل ونصف ب ى مع ثلاثة أمثال ونصف ر س فبرهان[٧١] أشكال المقالة الثانية من أقليدس يكون ضرب ا خ[٦٧] في ا ض[٦٩] يساوي سطح ا ض[٦٩] في ا س وسطح ا ض في خ س[٦٨]. ولأن أحد قسمي ا ض[٦٩] مثل ونصف ا س وقسمه الآخر ثلاثة أمثال ونصف س خ[٦٨] فسطح[٧٢] ا ض[٦٩] في ا س يساوي مجموع[٧٣] سطحين أحدهما <ثلاثة أنصاف مربع> ا س — وهو واحد وتسعة أجزاء من أحد عشر فيكون تكسيره[٧٤] أربعة و ٢٩٠٠ من ٣٠٢٥ والسطح الآخر هو[٧٥] ثلاثة أمثال ونصف ر س في ا س وهو سطح يكون أحد ضلعيه ر س والآخر ستة و[٧٦] ٢٥ من ٥٥ . أما سطح ا ض في ر س فينحل[٧٧] أيضا إلى ضرب جزأي ا ض[٧٨] في ر س[redacted][٧٩] أى إلى[٧٩] ضرب اثنين وثمانية أجزاء من أحد عشر جزءا من واحد في ر س — فيحصل[٨٠] سطحٌ أحد ضلعيه ر س والآخر اثنان وثمانية أجزاء من أحد عشر من واحد — وإلى سطح ر س في ثلاثة أمثاله ونصف فيحصل ثلاثة مربعات / ر س ونصف مربعه . فحصل لنا < من > جميع أجزاء خ ض[٨١] سطح تكسيره أربعة و ٢٩٠٠ من ٣٠٢٥ من واحد وسطحان آخران مجموعهما سطحٌ أحد ضلعيه ر س وضلعه الآخر < ضعف > أربعة و ٣٠ من ٥٥ من واحد وثلاثة مربعات ونصف مربع ر س . فاذا أضفنا يكون نصفها مساويا لأجزاء سطح خ ى[٨٢] المستطيل . ولأن[٨٣] سطح خ ب[٨٤] إذا فصل منه مستطيل خ ى[٨٢] يبقى مستطيل س ب وإذا فصل منه مثلث ا خ ذ[٨٥] يبقى منحرف ا ذ كب ب[٨٦] فيكون مستطيل س ب مساويا لمنحرف ا ذ كب ب[٨٧]. ولأن ب ى واحد وتسعة أجزاء

٦٣ – ك ، ل : ح ص ٦٤ – ك ، ل : وهو ٦٥ – ك ، ل . ا ح ٦٦ – ل : ا ص
٦٧ – ك ، ل : ا ح ٦٨ – ك ، ل : ح س ٦٩ – ك ، ل : ا ص ٧٠ – ك ، ل : وهو
٧١ – ك ، ل : فبرهان ٧٢ – ل : كرر الناسخ كتابتها ٧٣ – ل : فوق السطر ٧٤ – ك ، ل : تكسير
٧٥ – ك ، ل : وهو ٧٦ – ل : ناقصة ٧٧ – ك ، ل : ينحل ٧٨ – ل : ا ص
٧٩ – ك ، ل : أما ٨٠ – ك ، ل : يحصل ٨١ – ك ، ل : ح ض ٨٢ – ك ، ل : ح ى
٨٣ – ل : لأن ٨٤ – ك ، ل : ح ب ٨٥ – ك ، ل : ا ح ظ ٨٦ – ك ، ل : ا ظ كب ب
٨٧ – ك : ا ظ كب ب ، ل : ا ط كب ب

ولأن م ى ضعف و ب(٤٠) و بجى ٣٠٢٥(٤١) أمثال ى جب و يد بج ٧٢٥ أمثاله ونسبة ن م إلى م ى كنسبة يد بج(٤٢) إلى جى فيكون ن م ٧٢٥ جزءا بالمقدار الذي < به > يكون م ى ٣٠٢٥ . وهو ضعف و ب ، وبالمقدار الذي < به > يكون و ب ٣٠٢٥ فيكون ن م ١٤٥٠ .

وقد ذكرنا أن ى ل مثل وثلاثة أرباع ب و الواحد ، فسطح ى ن(٤٣) < في ى ل هو سطح م ى > — الذي هو اثنان — و م ن(٤٤) — وهو ١٤٥٠ (٤٥) من ٣٠٢٥ من الواحد(٤٦) — في ى ل الذي هو واحد وثلاثة أرباع ، فيكون(٤٧) تكسيره أربعة <و> ١٠٢٥ من ٣٠٢٥ من واحد . وهو تكسير مربع ك ى لأن ضرب ن ى في ى ل يساوي مربع ك ى . ولأن س ف ضعف(٤٨) ك ى و ص ق(٤٩) نصف س ف يكون ص ق مساوي ك ى ومربعه مربعه ، ومربع ص ق يساوي س ق في(٥٠) ق ع فيكون تكسير سطح س ق في ق ع أربعة و ١٠٢٥ من ٣٠٢٥ من واحد. ولأن ق ش ثلاثة بالمقدار(٥١) الذي به يكون ش ت(٥٢) أربعة ونسبة س ر إلى ر ق كذلك فيكون ر ق ثلاثة أسباع ق س و ر س أربعة أسباعه . فيكون سطح ع ق في ر س أربعة أسباع ع ق في(٥٣) ق س المذكور تكسيره ، وسطح ع ق في ر س هو(٥٤) سطح ع ث لأن ق س يساوي س خ(٥٥) و س خ(٥٥) مثل س ر . فسطح ع ث اثنان و ١٤٥٠ من ٣٠٢٥ وسطح ر خ(٥٦) مربع ر س(٥٧) وسطح ر ث ثلاثة أرباع مربعه . ولأنا فصلنا س ع خمسة [و ٢٥ من خمسة](٥٨) و ٢٥ من ٥٥ / <من> واحد يبقى ع ى من(٥٩) تمام العشرة أربعة و ٣٠ من ٥٥ من واحد . فجميع سطح خ ى(٦٠) المستطيل يساوي مربع ر س — وهو سطح ر خ(٦١) — وثلاثة أرباع مربعه — وهو سطح ر ث — وسطحاً تكسيره اثنان ١٤٥٠ من ٣٠٢٥ من واحد — وهو(٦٢) سطح ث ع — وسطحا أحد ضلعيه ر س وضلعه

٤٠ — ل : ى ب ٤١ — ل ١٠٢٥ ٤٢ — ل : يد ى ٤٣ — ل : ن ى ن ٤٤ — ك ، ل و ه
٤٥ — ك ، ل : ١٤٥ ٤٦ — ل : واحد ٤٧ — ك ، ل : يكون ٤٨ — ل : ضعيف
٤٩ — ل : ض ق ٥٠ — ل : و ٥١ — ك ، ل : المقدار ٥٢ — ك ، ل : ش ث ٥٣ — ل : ناقصة
٥٤ — ك ، ل : وهو ٥٥ — ك ، ل : س ح ٥٦ — ك ، ل : ر ح ٥٧ — ل : ر ك
٥٨ — زائده في ل فحسب ٥٩ — ك ، ل : في ٦٠ — ك ، ل : ح ى ٦١ — ك ، ل : ر ح
٦٢ — ل : كتبها الناسخ فوق السطر .

ونخرج من نقطة ح(١٨) خطا يوازي خط ز و وهو خط ح ى(١٩) ثم نخرج من نقطة ى خط ى س يوازي ا ب ونخرج(٢٠) خط س ى على استقامته إلى نقطة ل حتى(٢١) يكون خط ى ل مثل ب و وثلاثة أرباعه . ونجعل ى ه مثلي(٢٢) ب و . ثم يتعلم نقطـــة جب ونجعل خط جب جد ٣٠٢٤ مثل خط ى جب . ثم نجعل خط جد يد ٧٢٥ أمثالاً لخط ى جب ونصل خط جه ونخرج خط يد ن موازيا له وندير على قطر ن ل نصف دائرة ثم نجعل خط س ع خمسة أمثال(٢٣) وخمسة أجزاء من أحد عشر [redacted] جزءا من خط ب و . ولأن قطر س ع أعظم من قطر ن ل فلنا أن نخرج من نقطة س في دائرة س ع وترا مساويا لضعف ك ى وهو س ف . ونقسم قوس س ف بنصفين على ص ونخرج من نقطة ص عمود ص ق ثم نعلم نقطة ش على ص ق كيف <ما> وقعت . ونجعل(٢٤) ش ت مثل وثلث ق ش ونصل(٢٥) خط ت س(٢٦) ونخرج من ش خط ش ر موازيا له ونجعل س خ(٢٧) مثل س ر ونخرج خ كب يوازي ا ب ثم نجعل د لب مثلي ونصف ب كب ونخرج لب لج يوازي ا ب ، ونجعل ا ض مثل ونصف ب ى مزيداً عليه ثلاثة أمثال ونصف ى كب ونخرج ض لا ثم نخرج ا ذ(٢٨) جع(٢٩) .

فأقول إن المربع قد انقسم على الجهة المطلوبة وهي أن منحرف ا ب ذ كب(٣٠) ضعف سطح ذ غ لب كب(٣١) ومنحرف ا ذ غ ج(٣٢) خمسة(٣٣) أمثاله ومنحرف جد لب غ(٣٤) ثلاثة(٣٥) أمثاله(٣٦) .

برهان ذلك : لأن ب ط عشرة أمثال ب ه ونسبة د ب إلى ب و كنسبة ط ب إلى ب ه فيكون د ب عشرة أمثال ب و ونسميه الواحد . ولأن ز ب ٥٥ أمثال ب ظ(٣٧) و ز ح ٤٥ مثلاً له يكون نسبة ز ب إلى ز ح كنسبة ٥٥ إلى ٤٥ ونسبة(٣٨) ب و إلى و ى كنسبة ٥٥ إلى ٤٥(٣٨) فيكون و ى تسعة أجزاء على(٣٩) أن و ب الواحد أحد عشر جزءا .

١٨ – ك ، ل : خ ١٩ – ك ، ل : خ ى ٢٠ – ل : ونخرج من ٢١ – ل : إلى أن ٢٢ – ل : مثل
٢٣ – ك ، ل : أمثاله ٢٤ – ك ، ل : ونزيد عليه ٢٥ – ل : ونخرج ٢٦ – ك ، ل ث س
٢٧ – ك ، ل : س ح ٢٨ – ك : ا ظ ، ل : ا ط ٢٩ – ل : جع ٣٠ – ك : ا ب ظ كب ،
ل ا ب ط كب ٣١ – ك ظ ن غ لب كب ، ل : ص ع لب كب ٣٢ – ك ، ل : ا ظ ع ج
٣٣ – ك ل ثلاثة ٣٤ – ك ، ل : جد لب ع ٣٥ – ك ، ل : خمسة ٣٦ – أي أمثال المستطيل
٣٧ – ل : ب ط ٣٨ – .. ٣٨ – ما بينهما نساه الناسخ في ل ثم أعاد كتابته في الهامش ٣٩ – ل : ناقصة

بسم الله الرحمن الرحيم (١)

الحمد لله رب العالمين والصلوة والسلام على رسوله محمد وآله أجمعين .

مسألة(٢) سألها شمس الدين* أمير الأمراء النظامية عن الإمام الأجل الأوحد العالم شرف الدين بهاء الإسلام حجة(٣) الزمان مظفر(٤) بن محمد(٤) المظفر الطوسي أدام الله توفيقه ببلد همدان سنة ست(٥) وستمائة(٦) هجرية .

عن مربع متساوي الأضلاع كلّ ضلع منه معلوم وأردنا أن نقسمه إلى أربعة(٧) سطوح(٨) أحدها(٩) سطح متوازي الأضلاع مستطيل ، في الوسط ، وثلاثة منحرفات(١٠) تحيط به(١١) من ثلاثة جوانب على(١٢) هذا المثال على وجه تكون السطوح الأربعة بعضها إلى بعض < على > نسبة مفروضة معلومة وقد عُيِّن ضلع المربع ونسبة السطوح : يقال كل ضلع من أضلاع المربع عشرة والمطلوب أن يكون السطح المتوازي الأضلاع الذي في الوسط نصف المنحرف الذي على أحد(١٣) جانبيه والمنحرف الذي فوقه ثلاثة أمثاله والمنحرف الذي على الجانب الآخر منه خمسة أمثاله .

مثال ذلك : مربع ا ب ج د متساوي الأضلاع وضلع ا ب عشرة وأردنا العمل المذكور ، فنخرج ضلع < ا ب > على استقامته ويتعلم عليه نقطة ه كيفما اتفقت(١٤) ونزيد على خط ب ه تسعة أمثاله فيكون خط ب ط عشرة أمثال خط ب ه ونصل ط د ونخرج من نقطة ه خط ه و ويوازي ط د ثم يتعلم نقطة ظ على خط ب ه ، نقطة ظ كيفما وقعت(١٥) . ونجعل ظ ز ٥٤ مثل ب ظ(١٦) وخط ز ح(١٧) ٤٥ مثل ب ظ ونصل ز و /

١ – ل : تعقبها " وبه ثقتي " ٢ – ك : مسئلة ٣ – ك : حجب ٤ – ل : كتبها الناسخ أولا " محمد " ثم كتب فيما بعد مظفر فوقها . ٥ – ك : ناقصة وفي ل : ستة ٦ – ك : وخمس مايه ٧ – ك ، ل : أربع ٨ – ل : اسطوح ٩ – ل : كتبت أولا احداهما ثم رجع الناسخ وكتب فوق " هما " " ها " ١٠ – ل : متحرفات ١١ – ك ، ل : بها ١٢ – ل : على كل ١٣ – ل : ناقصة ١٤ – ل : اتفق ١٥ – ل : بدأ الناسخ بكتابه وقعت ثم عدل عن هذا وكتب اتفقت ١٦ – ل : بط ، ك : ب ط ١٧ – ل ، ك : رخ

* من الواضح أن هذا لقب ، ولم نهتد إلى معرفته من الدراسات التي رجعنا إليها عن المدرسة النظامية .

تقديم

لقد حققنا نص شرف الدين الطوسي على مخطوطتين :

الأولى هي مخطوطة جامعة كولومبيا Smith MS. Or. 47 من صفحة ٢٩ إلى صفحة ٣٥ . وهي مخطوطة من القرن الثالث عشر حسب تقدير مصنف مخطوطات مكتبة جامعة كولومبيا . ولقد أشرنا بحرف ك إلى هذه المخطوطة .

الثانية هي مخطوطة ليدن Or. 14 من صفحة ٣٢٣ وجه الى ٣٢٦ ظهر . ومن المعروف من فهارست دوزي أن هذه المخطوطة قد نُسخت في القرن السابع عشر وسنشير لها بحرف ل . وسنبين في تحقيقنا لجبر عمر الخيام أصلها ، ويكفينا الآن أن نقول إن المخطوطتين ترجعان إلى نفس الأصل بل من المؤكد أن مخطوطة كولومبيا هي أقرب إلى الأصل للأسباب التالية :

ــ ١ ــ باستثناء ثلاثة أخطاء في ك نجد كل أخطاء ك مع كثرتها في ل والعكس غير صحيح .

ــ ٢ ــ ينقص ل خمس كلمات نجدها في ك بينما ينقص ك كلمة واحدة موجودة في ل .

ــ ٣ ــ كل ما يجب إضافته إلى ك من كلمات وعبارات حتى يستقيم المعنى يجب أيضا إضافته إلى ل .

والمخطوطتان تحتويان على أخطاء عديدة زادها الخلط بين حروف الرسم الهندسي واستعمال نفس الحرف ظ للدلالة على نقطتين مختلفتين في الرسم .

واستعملنا الرموز التالية في التحقيق :

< > ما بينهما كلامنا

[ ] نقترح حذف ما بينهما

/ انتهاء صفحات ك

■ انتهاء صفحات ل

وأغلب النص غير منقوط ولقد قمنا بتنقيطه دون الإشارة إلا إذا تعددت الاحتمالات فأثبتنا نص المخطوطة في أسفل الصفحة ، ولقد أعدنا الرسم حتى يوافق النص .

est égal au rapport de la base $B\Delta$ à la base ΠD, suivant la quantité qui rend $B\Delta$ égal à deux, alors ΠD est cinq, car il est égal à deux fois et demie celui-ci; on a donc le trapèze $CD\Pi\Omega$ cinq parties de onze parties du grand carré. Puisque le rapport du triangle AXZ, qui est égal au rectangle WJ, au triangle $C\Omega\Psi$, est égal au rapport de la base XZ à la base $\Omega\Psi$, qui est deux et demi,[1] le triangle $C\Omega\Psi$ [redacted] / est donc deux fois et demie AXZ, et leur somme est trois fois et demie le rectangle WJ.

Puisque le rectangle $A\Psi$ est composé du produit du côté du grand carré par les deux parties de AX, dont l'une est une fois et demie BJ et l'autre est trois fois et demie WS, et que ceci est égal à la somme des deux triangles plus le trapèze $C\Omega ZA$, si donc on sépare les deux triangles de la surface $A\Psi$, cela revient à en séparer la surface < obtenue > du côté du grand carré par trois fois et demie WS. On a donc le trapèze $C\Omega ZA$ égal au produit du côté du grand carré par une fois et demie BJ. On a donc le trapèze $C\Omega ZA$ une fois et demie la surface BS, soit la surface $AZ\Delta B$; suivant la quantité qui rend le trapèze / $CD\Pi\Omega$ égal à cinq, il reste la surface $\Omega\Pi\Delta Z$ égale à un. Elle est donc un, ce qui est cherché.

On attend de la générosité du Seigneur Bienfaiteur – que Dieu perpétue son Eminence – qu'il examine et médite cette proposition, et pardonne les petites négligences, seulement si elles ont lieu dans certains de ses calculs particuliers.

S'il rencontre une erreur dans certaines de ses démonstrations, qu'il nous avertisse, cela sera utile à la question qu'il pose, car nous aurions été aveuglé par la multiplicité des prémisses, et par le mélange des prémisses géométriques à l'arithmétique; et qu'il ne blâme pas la longueur excessive de ces prémisses, car atteindre [redacted] l'objet d'une recherche démonstrative, par la multiplicité des prémisses et des propositions intermédiaires, tout en se préservant de l'erreur, si on s'en préserve,[2] cela se fera par l'habitude et par l'exercice. Et j'indique qu'atteindre le but dans les sciences théoriques augmente nécessairement les prémisses de leurs démonstrations, et leurs propositions intermédiaires. Ce sont là les plus grands enseignements des sciences mathématiques.

Certes, j'ai évité de m'étendre sur les prémisses des démonstrations de cette proposition, bien qu'elles soient véritablement nécessaires pour mener avec profit au résultat cherché.

Si par la suite le Seigneur Bienfaiteur en exprime le désir, j'exposerai les différentes méthodes à son éminent jugement critique, si Dieu le veut.

Que la paix soit.

1. Littéralement: deux fois plus un demi.
2. Littéralement: si cela est.

est le carré de *RS*, et la surface *RV* est trois quarts de ce carré. Mais comme on a séparé *SO* égal à cinq plus vingt-cinq cinquante cinquièmes / d'unité, il reste de dix entiers *OJ* égal à quatre plus trente cinquante cinquièmes.

Le rectangle *WJ* tout entier est égal au carré de *RS*, qui est la surface *RW* plus les trois quarts de son carré, qui est la surface *RV* plus une surface dont la mesure est deux plus mille quatre cent cinquante trois mille vingt cinquièmes d'unité, qui est la surface *VO* et une surface dont un côté est RS et l'autre côté est quatre plus trente cinquante cinquièmes d'unité, qui est la surface *O*Δ restante.

Puisque la surface *WX* est le produit de *AW* par *AX* et que *AW* est égal à *B*Δ qui est un plus neuf parties de onze parties d'unité, augmenté de *SW*, soit *RS*, et que le côté *AX* est une fois et demie *BJ* plus trois fois et demie *RS*, alors, par la démonstration des propositions du *Livre II* d'Euclide, on a le produit de *AW* par *AX* égal à la surface *AX* par *AS* plus la surface *AX* par *WS*. Puisque l'une des deux parties de *AX* est une fois et demie *AS*, et que l'autre partie est trois fois et demie *SW*, la surface *AX* par *AS* est égale à la somme des deux surfaces, dont l'une est trois demies du carré de *AS* qui est un plus neuf parties de onze parties, et sa mesure est donc quatre plus deux mille neuf cent trois mille vingt cinquièmes; l'autre surface est trois fois et demie *RS* par *AS*, qui est une surface dont l'un des deux côtés est *RS*, et l'autre est six plus vingt-cinq cinquante cinquièmes.

Quant à la surface *AX* par *RS*, elle se décompose également en les produits des deux parties de *AX* par *RS* [redacted], soit en le produit de deux plus huit parties de onze parties d'unité par *RS* – on obtient donc une surface dont un côté est *RS*, et l'autre est deux plus huit parties de onze parties d'unité; et en la surface de *RS* par trois fois et demie lui-même, – on obtient trois carrés / de *RS* plus la moitié de son carré.

On obtient donc de toutes les parties de *WX* une surface dont la mesure est quatre plus deux mille neuf cents trois mille vingt cinquièmes, plus deux autres surfaces dont la somme est une surface dont l'un des côtés est *RS*, et l'autre côté le double de quatre plus trente cinquante cinquièmes d'unité, plus trois carrés de *RS* et la moitié de son carré. Si on additionne le tout, on a la moitié égale aux parties du rectangle *WJ*. Puisque si de la surface *WB*, on sépare le rectangle *WJ*, il reste le rectangle *SB*, et si on en sépare le triangle *AWZ*, il reste le trapèze *AZ*Δ*B*, on a alors le rectangle *SB* égal au trapèze *AZ*Δ*B*. Puisque *BJ* est un plus neuf parties de onze parties, et que sa moitié est dix parties de onze parties d'unité, et que si on divise les dix en onze parties, chaque partie sera dix parties de onze parties d'unité, alors *BJ* est deux parties de onze parties de *BD*, qui est dix, et la surface *BS* à la surface *BC* est dans le même rapport; alors le trapèze *AZ*Δ*B* est deux parties de onze parties du carré *ABCD*; mais puisque le rapport du trapèze *AZ*Δ*B* au trapèze *CD*ΠΩ

abaissons la perpendiculaire UQ et marquons le point Ξ sur UQ – peu importe où il se trouve – et posons ΞT égal à une fois plus un tiers $Q\Xi$, et joignons TS; menons de Ξ la droite ΞR parallèlement à elle. Posons SW égal à SR. Menons $W\Delta$ parallèle à AB. Posons ensuite $D\Pi$ deux fois et demie $B\Delta$. Menons $\Pi\Lambda$ parallèle à AB. Posons AX une fois et demie BJ, augmenté de trois fois et demie $J\Delta$. Menons $X\Psi$ et menons ensuite AZ, $C\Omega$. Je dis alors que le carré a été divisé de la manière cherchée, c'est-à-dire que le trapèze $ABZ\Delta$ est deux fois la surface $Z\Omega\Pi\Delta$, le trapèze $AZ\Omega C$ est son quintuple, et le trapèze $CD\Pi\Omega$ est son triple.

Démonstration:

Puisque BI est dix fois BE, et que le rapport de DB à BF est égal au rapport de IB à BE, on a donc DB dix fois BF, on l'appelle alors l'unité. Puisque GB est 55 fois $BY/$, et GH 45 fois celui-ci, on a le rapport de GB à GH égal au rapport de 55 à 45, et le rapport de BF à FG est égal au rapport de 55 à 45.

On a donc FJ égal à neuf parties, étant donné FB, l'unité, onze parties. Puisque MJ est le double de FB, et que ΣJ est 3025 fois $J\Theta$, et que $\Gamma\Sigma$ est 725 fois celui-ci, et que le rapport de NM à MJ est égal au rapport de $\Gamma\Sigma$ à ΣJ, on a NM 725 parties, suivant la quantité qui rend MJ égal à 3025. Mais <MJ> est le double de FB; on a alors NM égal à 1450, suivant la quantité qui rend FB égal à 3025.

Mais on a indiqué que JF est une fois plus trois quarts BF, l'unité. Donc la surface JN par JL est la surface de MJ qui est deux plus MN qui est mille quatre cent cinquante trois mille vingt cinquièmes d'unité,[1] par JL qui est un plus trois-quarts; sa mesure est donc 4 plus mille vingt-cinq trois mille vingt cinquièmes d'unité, qui est la mesure du carré de KJ, car le produit de NJ par JL est égal au carré de KJ. Puisque SP est le double de KJ et que UQ est la moitié de SP, on a UQ égale KJ, et leurs carrés sont égaux. Le carré de KJ est égal à SQ par QO; on a donc la mesure de la surface SQ par QO 4 plus mille vingt-cinq trois mille vingt cinquièmes d'unité. Puisque $Q\Xi$ est trois suivant la quantité qui rend ΞT égal à quatre, et que le rapport de SR à RQ est le même, on a donc RQ trois septièmes de QS, et RS est ses quatre septièmes. On a donc la surface OQ par RS quatre septièmes de OQ par QS, dont on a rappelé la mesure; et la surface OQ par RS est la surface OV, car QV est égal à SW et SW égale SR, donc la surface OV est deux plus mille quatre cent cinquante trois mille vingt cinquièmes, et la surface RW

1. Littéralement: 1450 de 3025 de l'unité, formulation difficilement intelligible en français. Nous avons adopté, dans ce cas comme dans les autres semblables, des traductions équivalentes à celle donnée ci-dessus, quitte à changer les chiffres en mots.

Traduction

Au nom de Dieu Clément et Miséricordieux. Grâces lui soient rendues, et bénédiction à Muḥammed son prophète, et à toute sa famille.

Problème posé par Shams al-Dīn, Prince des Princes de al-Niẓāmiyya, au très illustre et unique Imām, Sharaf al-Dīn, gloire de l'Islam, figure de l'Histoire,[1] Muẓafar bin Muḥammed al-Muẓafar al-Ṭūsī, que Dieu perpétue sa réussite.

Dans la ville de Hamadān, l'année six cent six de l'Hégire.

Au sujet d'un carré dont chacun des côtés est connu, et qu'on veut partager en quatre surfaces. L'une, au milieu, est un rectangle, et trois trapèzes l'entourent de trois côtés, de sorte que les quatre surfaces sont les unes aux autres dans un rapport donné connu. Que le côté du carré et le rapport des surfaces soit déterminé: disons que chacun des côtés du carré soit dix; ce qu'on cherche est que le rectangle qui est au milieu soit la moitié du trapèze qui est sur l'un de ses côtés, que le trapèze qui est au-dessus de lui soit son triple, et que le trapèze qui est sur l'autre côté soit son quintuple.

Exemple: le carré $ABCD$ a des côtés égaux, et le côté AB est dix, et on veut la construction indiquée.

Prolongeons le côté AB jusqu'à un point E quelconque, et ajoutons à la droite BE neuf fois elle-même: on a donc la droite BI dix fois la droite BE. Joignons ID, et menons du point E la droite EF, parallèle à ID. On marque un point Y sur la droite BE – peu importe où se trouve Y.

Posons YG 54 fois BY, et GH 45 fois BY; joignons GF/. Menons du point H une droite parallèle à la droite GF, qui est la droite HJ. Menons ensuite du point J la droite JS, parallèle à AB, et prolongeons SJ jusqu'au point L, de sorte que la droite JL soit égale à BF plus ses trois-quarts.

Posons JM deux fois BF, et marquons ensuite le point Θ; posons la droite $\Theta\Sigma$ 3024 fois la droite $J\Theta$, et posons ensuite la droite $\Sigma\Gamma$ 725 fois la droite $J\Theta$.

Joignons la droite ΣM, et menons la droite ΓN parallèle à celle-ci. Traçons sur le diamètre NL un demi-cercle, et posons ensuite la droite SO cinq fois plus cinq parties de onze [redacted] parties de la droite BF. Puisque le diamètre SO est plus grand que le diamètre NL, on peut donc mener du point S dans le cercle SO une corde, SP, égale au double de KJ.

Partageons l'arc SP en deux parties égales, au point U. Du point U

1. Littéralement: preuve du temps.

dans ce type de problèmes de construction géométrique à la règle et au compas, mais traité par un algébriste, deux traductions successives: une traduction algébrique du problème géométrique, qui ramène à une équation algébrique; une traduction géométrique du problème algébrique, destinée à répondre au problème initial par une construction (l'intersection d'un cercle et d'une droite).

Cette notable différence entre la solution des problèmes de construction géométrique traités par les algébristes, et l'étude des mêmes problèmes par les géomètres – le célèbre problème de la trisection de l'angle, par exemple – tient à cette double traduction. Elle n'exprime pas seulement de nouveaux rapports entre algèbre et géométrie, mais encore elle infléchit le sens même du terme d'analyse dans un débat célèbre sur l'analyse et la synthèse.

Mais une telle démarche n'apparaît pas pour la première fois chez al-Ṭūsī; elle est déjà suivie par ses prédécesseurs, al-Khayyām par exemple, pour traiter de problèmes plus difficiles que celui d'al-Ṭūsī, comme la division d'un quart de cercle en deux parties en un point, sous certaines conditions; ceci fera l'objet d'une prochaine étude.

Préface à la Traduction

Le texte que nous présentons ainsi que sa traduction a été établi à partir de deux manuscrits:

1. Smith MS. Or. 47, Columbia University, pp. 29-35. Vraisemblablement copié au XIIIème siècle.

2. Leiden Or. 14, ff. 323^r — 326^v. Copié au XVIIème siècle à la demande de Golius. Voir le catalogue de Dozy.

Les deux textes renvoient au même archétype pour les raisons suivantes:

(1) Sur 116 accidents, on en trouve seulement 3 dans le manuscrit de Columbia qui ne soient pas dans le manuscrit de Leiden, la réciproque n'est pas vraie: des dizaines d'accidents figurent simplement dans ce dernier.

(2) Il manque au manuscrit de Leiden cinq mots que l'on trouve tous dans le manuscrit de Columbia; tandis qu'il manque à ce dernier un seul mot qui figure dans le premier.

(3) Ce qu'il faut ajouter pour établir le sens du texte est nécessaire dans les deux cas.

Enfin, plusieurs accidents sont provoqués par l'usage d'une même lettre pour désigner deux points différents de la figure géométrique.

Nous avons indiqué les pages du manuscrit de Columbia par / et celles du manuscrit de Leiden par ▮.

Mais pour achever l'analyse, il faut encore pouvoir placer la droite δ. Il est donc nécessaire de procéder à une deuxième construction pour obtenir un segment de longueur l telle que

$$l^2 = \frac{525}{11^2}$$

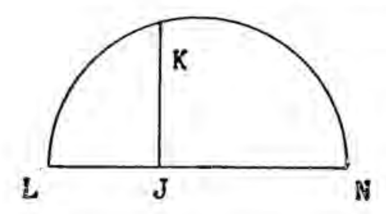
On détermine alors l comme moyenne géométrique entre les deux longueurs l_1, l_2 telles que:

$$l_1 \cdot l_2 = \frac{525}{11^2} \quad , \quad l_1 \text{ et } l_2 \text{ rationnels.}$$

Al-Ṭūsī fait pour l_1 et l_2 le choix suivant:

$$l_1 = JL = \frac{7}{4} \qquad\qquad l_2 = JN = \frac{300}{121}\,.$$

On retrace le cercle de diamètre LN et on obtient le segment JK de longueur l, en utilisant la puissance du point J par rapport au cercle.



Telle est, nous semble-t-il, la voie de l'analyse qu'a suivie al-Ṭūsī. Elle nous permet de comprendre comment il a choisi les valeurs numériques particulières rencontrées dans la synthèse du problème, ainsi que les étapes successives de cette synthèse. On saisit en effet les raisons des différentes constructions et on comprend l'ordre de leur enchaînement.

Rien dans cette analyse ne peut surprendre: les notions et les techniques auxquelles elle fait appel sont parmi les plus élémentaires rencontrées dans son *Traité sur les Equations.*

Ainsi, après avoir tout d'abord suivi la voie d'une analyse algébrique pour étudier les inconnues x, y, z, t, il procède par une technique partout utilisée dans son *Traité*: les exprimer toutes au moyen des transformations affines d'une seule inconnue u. La traduction par des constructions géométriques des éléments de l'analyse algébrique donne ensuite la solution du problème géométrique posé.

Si l'hypothèse que nous venons de développer est juste, on rencontre

d'où $$y = \frac{80}{11} - \frac{7}{2} u .$$

D'autre part
$$AX = 10 - y = \frac{30}{11} + \frac{7}{2} u ,$$

d'où $$AX = \frac{3}{2} BJ + \frac{7}{2} J\Delta .$$

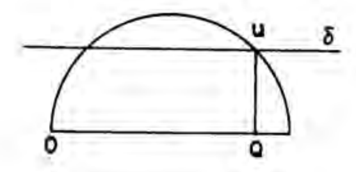
Il est donc clair que la solution du problème revient à le détermination de u.

$$S_1 = \frac{100}{11} \iff xy = \frac{100}{11} \iff (\frac{40}{11} - \frac{7}{2} u)(\frac{80}{11} - \frac{7}{2} u) = \frac{100}{11} ,$$

d'où $$(\frac{7}{2} u)^2 - \frac{60}{11}(\frac{7}{2} u) + \frac{525}{11^2} = 0 , \quad \text{avec } \frac{7}{4} u < \frac{20}{11} ,$$

d'où $$\frac{7}{4} u = \frac{60 - \sqrt{375}}{11} .$$

On a donc retrouvé par l'analyse précédente la plupart des valeurs numériques d'al-Ṭūsī. Mais la résolution algébrique de l'équation du second degré obtenue conduit à un nombre irrationnel, et ne pouvait par conséquent constituer une réponse au problème de construction posé. L'analyse exige donc que l'on détermine les deux racines de l'équation par des moyens pour ainsi dire constructifs : l'intersection d'un demi-cercle et d'une droite. Le cercle a nécessairement pour diamètre un segment SO de longueur $\frac{60}{11}$ (somme des racines) et la droite δ doit être telle que sa distance à la droite SO ait pour carré $\frac{525}{11^2}$ (produit des racines).



Mais si l'on tient compte de la condition $\frac{7}{4} u < \frac{20}{11}$, on constate que seule la racine QS convient pour le problème.

Seul, il est vrai, l'examen de la voie de l'analyse suivie par al-Ṭūsī peut éclairer les raisons de ce choix et de cet enchaînement. Et de fait la lecture de la conclusion de sa réponse est convaincante: le mathématicien y reconnait l'importance de l'analyse, particulièrement dans ce type de problèmes arithmético-géométriques; il y justifie son silence par des raisons de circonstances, à savoir la recherche délibérée de la brièveté dans sa correspondance.

Al-Ṭūsī considère en effet que l'analyse est nécessaire pour parvenir au résultat cherché et, plus généralement, qu'elle seule produit "les plus grands enseignements dans les sciences mathématiques". Aussi déclare-t-il à son correspondant que, bien qu'il passe outre et n'expose pas cette analyse, il se tient à sa disposition pour la lui communiquer, s'il en exprime le désir.

Pour nous, cependant, le résultat est le même: le texte ne nous offre aucune information sur l'analyse suivie par le mathématicien. Il ne nous reste qu'à tenter de reconstituer cette analyse à l'aide des seules notions en possession du mathématicien. Reprenons donc le problème d'al-Ṭūsī et posons:

$$S_1 = \text{le rectangle } Z\Omega\Delta\Pi$$
$$S_2 = \text{le trapèze } AB\Delta Z$$
$$S_3 = \text{le trapèze } CD\Pi\Omega$$
$$S_4 = \text{le trapèze } AZ\Omega C$$

tels que $S_2 = 2\,S_1 \;,\quad S_3 = 5\,S_1 \;,\quad S_4 = 3\,S_1 \,.$

Posons $\Delta\Pi = x \;,\quad \Delta Z = y, \quad \Pi D = z \;,\quad \Delta B = t \,.$

On a immédiatement:

$$S_1 = \frac{1}{11}(A, B, C, D) = \frac{100}{11}$$

$$S_2 = \frac{2}{11}(A, B, C, D) \iff S_2 = (B, J, S, A)$$

avec $BJ = \dfrac{2}{11} \;,\quad BD = \dfrac{20}{11} \,,$

$$S_3 = \frac{5}{2}\,S_2 \iff D\Pi = \frac{5}{2}\,B\Delta \,.$$

Soit $J\Delta = u$, une inconnue auxiliaire, on a

$$t = \frac{20}{11} + u \qquad z = \frac{50}{11} + \frac{5}{2}\,u$$

$$x = 10 - t - z = \frac{40}{11} - \frac{7}{2}\,u$$

$$S_4 = 3\,S_1 \iff \frac{(10-y)(10+x)}{2} = 3\,x\,y$$

On a donc $(W,J) = \frac{1}{2}(W,X) = (A, W, Z)$.

Mais $(W,B) - (W,J) = (B,S)$
et $(W,B) - (A,W,Z) = (B,\Delta,Z,A)$ } d'où $(B,S) = (B,\Delta,Z,A)$.

Mais $(B,S) = \frac{2}{11}(A, B, C, D)$,

d'où $(B, \Delta, Z, A) = \frac{2}{11}(A, B, C, D)$.

D'autre part les trapèzes (B, Δ, Z, A) et (D, C, Ω, Π) ont des bases égales et leurs hauteurs $B\Delta$ et $D\Pi$ sont dans le rapport $\frac{2}{5}$.

Donc $(D, C, \Omega, \Pi) = \frac{5}{11}(A, B, C, D)$.

On a $(A, Z, \Omega, C) = (A,\Psi) - \left[(A, X, Z) + (C, \Omega, \Psi)\right]$

Mais $(C, \Omega, \Psi) = \frac{5}{2}(A, X, Z)$,

d'où
$$\begin{aligned}(A, Z, \Omega, C) &= (A, \Psi) - \frac{7}{2}(W, J)\\ &= AC{\cdot}AX - \frac{7}{2}AC{\cdot}WS\\ &= AC\left(\frac{3}{2}AS + \frac{7}{2}WS - \frac{7}{2}WS\right) = \frac{3}{2}AC{\cdot}AS\\ &= \frac{3}{2}(B,S) = \frac{3}{11}(A, B, C, D).\end{aligned}$$

Finalement, si on retranche du carré (A, B, C, D) les trois trapèzes, il reste le rectangle (Ω, Π, Δ, Z) qui est donc $\frac{1}{11}$ de (A, B, C, D).

L'exposé d'al-Ṭūsī, ainsi que le montre le précédent résumé, est strictement synthétique. A aucun moment, ou presque,[1] le mathématicien ne dévoile les raisons pour lesquelles il a choisi les valeurs numériques particulières des différentes constructions. Il n'explique pas davantage l'ordre d'enchaînement de ces constructions.

1. On a $S_1 = \frac{1}{11}(A, B, C, D)$. On a également dès le départ le point J défini par $BJ = \frac{2}{11}BD$, et tel que le rectangle (A,J) soit les $\frac{2}{11}$ du carré; donc (A,J) est égal au trapèze S_2 cherché.

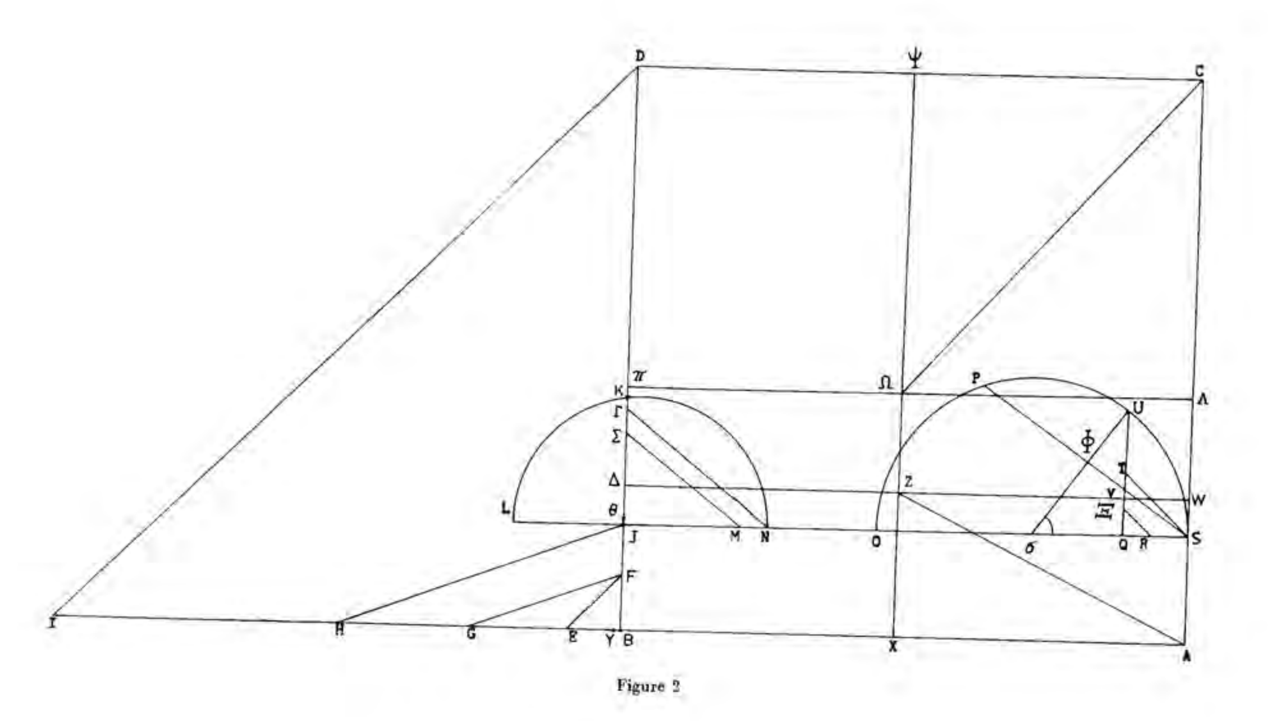


Figure 2

d'où $$JN = JM + MN = \frac{300}{121} BF.$$

Mais $JN \cdot JL = \overline{JK}^2$, puissance de J par rapport au cercle de diamètre NL.

On a $$\overline{JK}^2 = \frac{300}{121} \times \frac{7}{4} \overline{BF}^2 = \frac{525}{11^2} \overline{BF}^2 .$$

Mais comme $SP = 2KJ$, U est le milieu de $\widehat{SP}$. $UQ \perp SO$, l'égalité des triangles rectangles $S\sigma\Phi$ et $U\sigma Q$ donne $UQ = S\Phi = \frac{1}{2} SP$ d'où $UQ = KJ$

On a $SQ \cdot QO = \overline{UQ}^2$ puissance de Q par rapport au cercle de diamètre SO,

d'où $$SQ \cdot QO = \frac{525}{11^2} \overline{BF}^2 .$$

D'après la construction de R, on a

$$RQ = \frac{3}{7} QS \quad \text{et} \quad RS = \frac{4}{7} QS,$$

d'où $$OQ \cdot RS = \frac{4}{7} \cdot \frac{525}{11^2} \overline{BF}^2 .$$

Mais $$OQ \cdot RS = OQ \cdot QV = (O,V)$$

car $$QV = SW = SR,$$

d'où $$(O,V) = \frac{4}{7} \cdot \frac{525}{11^2} \overline{BF}^2 .$$

On a $$(W,J) = (W,R) + (R,V) + (V,O) + (O,\Delta)$$

et $$(O,\Delta) = OJ \cdot J\Delta = OJ \cdot RS \quad \text{avec } OJ = \frac{50}{11} BF,$$

d'où $$(W,J) = \overline{RS}^2 + \frac{3}{4} \overline{RS}^2 + \frac{4}{7} \cdot \frac{525}{11^2} \overline{BF}^2 + \frac{50}{11} BF \cdot RS$$

$$= \frac{7}{4} \overline{RS}^2 + \frac{300}{11^2} \overline{BF}^2 + \frac{50}{11} BF \cdot RS .$$

D'autre part on a

$$(W,X) = AX \cdot AW = \left(\frac{3}{2} AS + \frac{7}{2} WS \right) (AS + WS)$$

$$= \frac{3}{2} \overline{AS}^2 + 5\, AS \cdot WS + \frac{7}{2} \overline{WS}^2$$

$$= \frac{3}{2} \left(\frac{20}{11} BF \right)^2 + 5 \cdot \frac{20}{11} BF \cdot RS + \frac{7}{2} \overline{RS}^2$$

$$= \frac{600}{11^2} \overline{BF}^2 + \frac{100}{11} BF \cdot RS + \frac{7}{2} \overline{RS}^2 = 2\,(W,J)$$

Traçons ΣM et $\Gamma N \ // \ \Sigma M$, N sur JS.

Posons $SO = 5\ BF + \frac{5}{11}\ BF = \frac{60}{11}\ BF$.

Traçons le demi-cercle de diamètre SO et menons de S dans ce demi-cercle une corde SP égale à $2\ JK$, ce qui est possible car $SO > LN$.

Soit U le milieu de $\widehat{SP}$, $UQ \perp SO$.

Soit Ξ arbitraire sur UQ et T tels que

$$\Xi T = \left(1 + \frac{1}{3}\right) Q\Xi \qquad \text{avec } \Xi \text{ et T sur } QU.$$

Traçons TS et $\Xi R // TS$, R sur SO. Plaçons W sur AC tel que $SW = SR$. De W menons $W\Delta \ // \ AB$, Δ sur BD.

Soit Π sur BD tel que : $D\Pi = \left(2 + \frac{1}{2}\right) B\Delta$. Par Π on mène $\Pi\Lambda \ // \ AB$, Λ sur AC.

Soit X sur AB tel que :

$$AX = \frac{3}{2}\ BJ + \left(3 + \frac{1}{2}\right) J\Delta$$

et $$X\Psi \ // \ BD \ , \ \Psi \text{ sur } CD.$$

Soit Z l'intersection de ΔW et $X\Psi$ et Ω l'intersection de $X\Psi$ et $\Lambda\Pi$, on a

le rectangle $Z\Omega\Delta\Pi$

le trapèze $ABZ\Delta$ tel que $(A,B,Z,\Delta) = 2\ (Z,\Omega,\Delta,\Pi)$

le trapèze $AZ\Omega C$ tel que $(A,Z,\Omega,C) = 5\ (Z,\Omega,\Delta,\Pi)$

le trapèze $CD\Pi\Omega$ tel que $(C,D,\Pi,\Omega) = 3\ (Z,\Omega,\Delta,\Pi)$

Démonstration :

BF est l'unité.

La construction de J donne $\frac{BF}{FJ} = \frac{11}{9}$,

d'où $$FJ = \frac{9}{11}\ BF \quad , \quad BJ = \frac{20}{11}\ BF\ .$$

La construction de N donne $MN = \frac{725}{3025}\ MJ = \frac{1450}{3025}\ BF$,

$$S_2 = 2S_1 \quad , \quad S_3 = 5S_1 \quad , \quad S_4 = 3S_1.$$

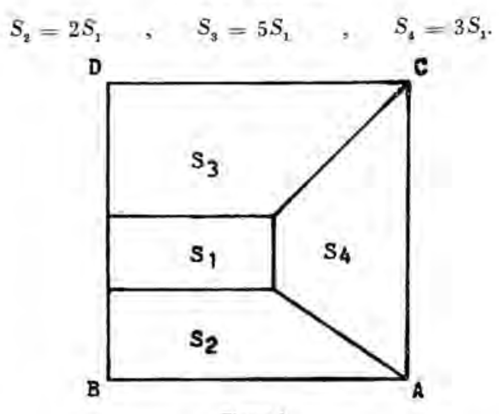


Figure 1

Il s'agit donc d'un problème de construction géométrique à l'aide de la règle et du compas. On peut penser, au premier abord, que ce problème de construction est totalement indépendant des réalisations algébriques d'al-Ṭūsī, telles qu'il les expose dans son *Traité sur les Equations*, et cette impression peut se trouver corroborée par l'exposé purement synthétique du mathématicien.

Toute la question est de savoir dans quelle mesure et en quel sens les notions et les instruments d'al-Ṭūsī algébriste ont pu trouver leur rôle dans l'étude d'un problème somme toute traditionnel, et, qui plus est, de circonstance. Seule une réponse à cette question permettra à l'historien qui ne se contente pas d'une simple description de classer ce mémoire dans l'oeuvre d'al-Ṭūsī. Mais avant d'esquisser cette réponse, résumons d'abord la solution d'al-Ṭūsī, en évitant, autant que possible, de nous écarter de son texte et de son style.

Soit $ABCD$ un carré tel que $AB = 10$, E un point arbitraire sur AB [voir figure 2].

On construit I tel que: $BI = 10\ BE$. Joignons ID et de E menons $EF\ //\ ID$. F sur BD. On a $BF = \frac{1}{10} AB$, d'où $BF = 1$.

Soit Y un point arbitraire sur BE, G et H tels que $YG = 54\ BY$, $GH = 45\ BY$. Joignons GF et menons $HJ//GF$. On a $BJ = \frac{20}{11} BF$ ou $BJ = \frac{2}{11} BD$. Soit Θ arbitraire sur BD. Σ et Γ tels que:

$$\Theta\Sigma = 3024\ J\Theta \quad \text{et} \quad \Gamma\Sigma = 725\ J\Theta.$$

Un problème arithmético-géométrique de Sharaf al-Dīn al-Ṭūsī

Roshdi Rashed*

L'œuvre strictement mathématique qui nous est parvenue de Sharaf al-Dīn al-Ṭūsī[1] se compose d'un *Traité sur les Equations* et de deux mémoires. Le *Traité*, nous l'avons montré ailleurs,[2] est l'un des ouvrages les plus importants dans l'histoire de l'algèbre classique: on pense y reconnaître les débuts de la géométrie algébrique.

Des deux mémoires, le premier, consacré à l'étude de l'asymptote à une branche d'une hyperbole équilatère, se révèle être une proposition de son précédent *Traité*. Nous considérons ailleurs[2] sa situation dans un classement de l'œuvre du mathématicien.

Dans le deuxième mémoire, que nous présentons ici, al-Ṭūsī étudie un problème arithmético-géométrique. Oeuvre de circonstance – il s'agit d'une réponse à une question posée par le Directeur de la célèbre école de Bagdad: al-Niẓāmiyya –, c'est là le dernier écrit mathématique d'al-Ṭūsī. D'Hamadān – l'ancienne Ecbatane – al-Ṭūsī expédiait à son correspondant la réponse à la question que voici:

Soit $ABCD$ un carré tel que $AB = 10$. On veut décomposer ce carré en quatre surfaces S_1, S_2, S_3, S_4, telles que:

S_1 soit un rectangle dont un côté est porté par BD.

S_2, S_3, S_4 soient des trapèzes obtenus en joignant les deux autres sommets du rectangle aux points A et C.

Soient S_2 le trapèze de base AB, S_3 le trapèze de base DC et S_4 le trapèze de base AC. On veut aussi:

* C. N. R. S., Paris.

1. Sur l'oeuvre de Sharaf al-Dīn al-Ṭūsī, voir nos études:

"Résolution des Equations numériques et Algèbre, Sharaf al-Dīn al-Ṭūsī, Viète", *Archive for History of Exact Sciences*, 13 (1974), 244-290.

"Recommencements de l'Algèbre aux XIème et XIIème Siècles" dans J. E. Murdoch and E. D. Sylla, *The Cultural Context of Medieval Learning* (Dordrecht, Reidel, 1975), pp. 33-60.

"L'Extraction de la Racine $n^{\text{ième}}$ et l'Invention des Fractions Décimales (XIème – XIIème Siècles)", *Archive for History of Exact Sciences*, 18 (1978), 191-243, et particulièrement les pages 208-213.

Voir également l'article "Ṭūsī, Sharaf al-Dīn", par A. Anbouba, in *Dictionary of Scientific Biography* (New York, Scribner's, 1970-1976).

2. Voir notre édition critique de ce *Traité* et sa traduction française, à paraître.

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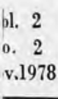
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